ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/227603637

Sensory characteristics of ice cream produced in the U.S.A. and ITALY

Article *in* Journal of Sensory Studies · May 2009

DOI: 10.1111/j.1745-459X.2009.00217.x

CITATIONS
58

READS
16,649

3 authors:

Kelly R. Thompson
California State University, Sacramento
3 PUBLICATIONS **76** CITATIONS
SEE PROFILE

Delores Chambers
Kansas State University
65 PUBLICATIONS **1,911** CITATIONS
SEE PROFILE

Edgar Chambers
Kansas State University
280 PUBLICATIONS **8,855** CITATIONS
SEE PROFILE

All content following this page was uploaded by Kelly R. Thompson on 22 October 2017.

The user has requested enhancement of the downloaded file.

SENSORY CHARACTERISTICS OF ICE CREAM PRODUCED IN THE UNITED STATES AND ITALY

By

KELLY R. THOMPSON

B.A., CALIFORNIA STATE UNIVERSITY, SACRAMENTO 2003

A THESIS

Submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Interdisciplinary Food Science Graduate Program
Department of Human Nutrition

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2007

Approved by:

Major Professor
Dr. Delores H. Chambers
Department of Human Nutrition

Abstract

This study was conducted to define and compare typical sensory characteristics of high quality Italian gelati to ice creams produced in the United States. Highly trained descriptive sensory panelists evaluated gelato samples in Italy, purchased direct from local gelaterias, and ice cream samples in the U.S., purchased from grocery stores and local shops. In general, gelati gave higher overall fruity and fruit ID scores, chocolate gelati gave higher chocolate and cocoa notes, and vanilla gelati gave higher vanilla and lower vanillin intensities than most U.S. ice creams. Gelati were consistently associated with higher density, lower firmness, and slower meltdown. When compared to U.S. ice creams, Italian gelati were characterized by specific sensory properties: “true to type” flavors; high intensity flavors that were considered to be typical to that flavor category or specific fruit and are combined with a dense, smooth texture that allows for the development of flavor, body and bloom, enhancing the perception of flavors. The research conducted in this study may be useful for ice cream manufacturers and sensory scientists. This study is the first to define sensory characteristics of high quality Italian gelati and the information may be used to produce ice cream with increased consumer liking. The descriptive attributes developed can be used for the development of new or improved of ice cream products.

Table of Contents

List of Figures v
List of Tables vi
Acknowledgements vii
CHAPTER 1 - Literature Review 1
Sensory Analysis 2
Flavor Profiling 2
Texture Profiling 3
Gelato 4
Ice Cream 6
Nutritional Aspects 6
Ice Cream Categories 7
Flavor Categories 8
Vanilla 8
Chocolate 8
Fruit 9
Formulation 9
Lexicon Development 10
References 12
CHAPTER 2 - Materials and Methods 18
Ice Cream Samples 18
Gelato Samples 18
Panelists 20
Product Orientation 20
Evaluation Procedures 21
Gelato 21
Ice Cream 22
Data Analysis 22
References 23

CHAPTER 3 - Sensory Characteristics of Ice Cream produced in the United States and Italy ... 24
Abstract ... 24
Introduction ... 25
Materials and Methods ... 26
Samples ... 26
Panelists ... 28
Lexicon Development ... 28
Evaluation Procedures ... 30
Data Analysis ... 31
Results and Discussion ... 31
Flavor Characteristics of Fruit Samples ... 32
Amplitude Characteristics of Fruit Samples ... 33
Texture Characteristics of Fruit Samples ... 34
Flavor Characteristics of Vanilla Samples ... 36
Amplitude Characteristics of Vanilla Samples ... 37
Texture Characteristics of Vanilla Samples ... 38
Flavor Characteristics of Chocolate Samples ... 39
Texture Characteristics of Chocolate Samples ... 41
References ... 44
Appendix A - Lexicon for the Flavor Evaluation of Ice Cream and Gelato ... 48
Appendix B - Lexicon for the Texture and Amplitude Evaluation of Ice Cream and Gelato ... 50
Appendix C - Homemade Gelato Recipes ... 52
Appendix D - Ice Cream Definition and Reference Sheet ... 59
Appendix E - Ice Cream and Gelato Ballot ... 67
Appendix F - Ice Cream Test Design ... 69
Appendix G - Gelato Test Design ... 71
Appendix H - Ice Cream Product List ... 73
Appendix I - Fruit Consensus Scores ... 75
Appendix J - Vanilla Consensus Scores ... 77
Appendix K - Chocolate Consensus Scores ... 79

List of Figures

Figure 3-1 The First Two Principal Components Analyzing Flavor of Fruit Ice Cream and Gelato Samples 33
Figure 3-2 The First Two Principal Components Analyzing Amplitude of Fruit Ice Cream and Gelato Samples 34
Figure 3-3 The First Two Principal Components Analyzing Texture of Fruit Ice Cream and Gelato Samples 35
Figure 3-4 The First Two Principal Components Analyzing Flavor of Vanilla Ice Cream and Gelato Samples 37
Figure 3-5 The First Two Principal Components Analyzing Amplitude of Vanilla Ice Cream and Gelato Samples 38
Figure 3-6 The First Two Principal Components Analyzing Texture of Vanilla Ice Cream and Gelato Samples 39
Figure 3-7 The First Two Principal Components Analyzing Flavor of Chocolate Ice Cream and Gelato Samples 40
Figure 3-8 The First Two Principal Components Analyzing Amplitude of Chocolate Ice Cream and Gelato Samples 41
Figure 3-9 The First Two Principal Components Analyzing Texture of Chocolate Ice Cream and Gelato Samples 42

List of Tables

Table 2-1 Ice Cream Flavors and Brands 19
Table 3-1 Ice Cream Flavors and Brands 27
Table 3-2 Sensory Descriptors for the Flavor Evaluation of Ice Cream and Gelato 29
Table 3-3 Sensory Descriptors for the Texture and Amplitude Evaluation of Ice Cream and Gelato 30

Acknowledgements

I would like to thank Dr. Delores Chambers, Dr. Edgar Chambers IV, and Dr. Betsy Barrett for their support and encouragement throughout this endeavor. I would also like to thank the Sensory Analysis Center for their assistance in the completion of my research project, and all of my fellow graduate students for their patience, understanding and support. I am extremely grateful for the never-ending support from my family and friends, especially my parents, because without their faith and encouragement I wouldn't be where I am today. Lastly, I would like to thank my biggest supporter Alisa. I appreciate all that she has done to help me reach this milestone in my life. She has been there for me through thick and thin, her patience and advice has kept me going and kept me sane even though it may have driven her crazy. Thank you Alisa, you are remarkable.

CHAPTER 1 - Literature Review

Descriptive analysis was used for evaluating Italian and American-made ice creams. Descriptive analysis methods involve detection and description of the sensory characteristics of a product by trained panels of five to thirty judges (Meilgarrd *et al.,* 1991). Descriptive tests are used to describe sensory characteristics of a product, and to use these characteristics to quantify differences between products. The outcome of descriptive analysis is a total sensory description, taking into account all visual, auditory, olfactory, taste and kinesthetic sensations that are perceived when the product is evaluated (Stone and Sidel, 1992). Some of the most commonly used descriptive methods are: the Flavor Profile® (Cairncross and Sjöström, 1950), the Texture Profile® (Brandt *et al*., 1963), the Quantitative Decsriptive Analysis (QDA®) Method (Stone *et al*. 1974; Stone and Sidel, 1992), the Spectrum™ Method (Meilgarrd *et al*., 1991) and the Dynamic Flavor Profile Method (DeRovira, 1996). Rating the descriptors for the sensory characteristics of appearance, odor, flavor, texture and after-taste will generate what is often referred to as the sensory profile of the product.

Oftentimes sensory information is required to make decisions about product quality. Many studies have measured sensory properties of ice cream to examine the relationship among various ingredients and sensory characteristics such as flavor and texture. King (1994) found that the nature of vanilla flavoring affects flavor perception and that modifying fat distribution influences flavor release. Replacement of milk fat with tapioca dextrin or potato maltodextrin also has significant effects on textural properties; increasing coarseness and wateriness and decreasing creaminess (Specter and Sester, 1994). Stampanoni-Koeferli *et al.* (1996) showed that the addition of fat increased the buttery and creamy notes as well as mouthcoating, while increases in sugar levels affect sweetness, caramel and vanillin attributes. Guinard *et al.* (1996) demonstrated that sugar and, to a lesser extent, fat were key determinants of ice cream acceptability and that too little or too much sugar or fat was detrimental to ice cream quality. Other studies also determined that higher fat content was an important factor affecting overall sensory quality of ice cream (Zheng et al., 1997; Roland et al., 1999; Ohmes et al., 1998). No studies were found related to factors affecting the sensory properties of Italian gelato.

There is little more than myths or innuendos associated with the "superiority" of Italian gelati as compared to typical ice cream. What is it about gelato that has allowed it to acquire this status? How is the ideal product described? What are the main attributes of this type of product? Sensory testing will be able to answer these types of questions and will be useful for the further development of lexicons associated with the desirable qualities useful for product development and/or education.

Sensory Analysis

Sensory analysis is used to characterize and measure sensory attributes of products. Sensory Analysis is the definition and scientific measurement of the attributes of a product perceived by the senses: sight, sound, smell, taste and touch. Since it's induction into the food world it has been transformed into an array of complementary product tests focusing on sensory questions. In the sensory description of food products there has been an evolvement of methods for describing the flavor of food products from relatively unreliable qualitative descriptions to highly reliable profiling and quantitative descriptive techniques (Piggott, J.R. and Paterson, A., 1994). By understanding sensory flavor data, one can offer food-product development scientists guidelines as to which property should be emphasized when making product-development decisions. This decision process includes processing ingredient and economic considerations. This has been encouraged by customer choice-driven markets and the need to identify the customers' ideals and expectations of sensory quality to help set sensory targets in the design and development of products (Lyon *et al*., 1992). For the purpose of this study sensory analysis will be useful in its approach towards product description, for determining the quality characteristics associated with Italian gelati, for describing what it tastes like, how it is perceived sensually and how it differs from its American counterpart, ice cream.

Flavor Profiling

Flavor is a combination of mouthfeel, taste and aroma. Many of the flavors in ice cream are identified by taste. This is accomplished by tasting the product and permitting the volatile flavor of the product in the mouth to pass over the taste buds and the olfactory organs in the back of the nostrils (Arbuckle, 1986). One then becomes familiar and experienced with a flavor and gains the ability to recognize it by memory whenever it occurs.

An adapted and modified flavor profile method was used for this research. The flavor profile method is a sophisticated descriptive technique developed by Jean Caul in the late 1940's (Caul, 1957). Flavor profiling is a consensus technique and is generally performed by a panel of four to six assessors who have received extensive training (a trained panel is more capable of describing the subtle differences between samples) (Chambers et al., 1981). This is not a simple process of averaging scores; the consensus is reached by discussion and reevaluation of the products by the panelists and panel leader. The panel members are responsible for developing the vocabulary that will be used to describe the product as well as the product evaluation itself (Lawless and Heymann, 1998). The flavor profile method is a preferred technique because it provides a collective response regarding the products' detectable factors, their intensities, and their order of detection (Mazzucchelli and Guinard, 1999).

Characterization of the perceived flavor of a food is a complex task (Amerine et al., 1965). The panel defines the character ratings of odor, flavor, taste and feeling factors and assigns ratings reflecting strength of note in the product. The panel also rates the overall degree of blend and amount of fullness present in the flavor as a whole: this is called amplitude (Lyon *et al.*, 1992). Amplitude is not supposed to be evaluated as the overall quality of the product, nor does it include the panelists' hedonic responses to the product. Amplitude is often misunderstood as it is designated as more of an impression than an exact flavor note, for this reason it is better to think of it as something you experience rather than understand.

Texture Profiling

The texture profile method was developed at General Foods Corporation in the early 1960's; the method was modeled after the Flavor Profile Method. Szczesniak (1963) then developed a texture classification system categorizing the perceived textural characteristics of products as three groups: mechanical, geometrical, and other characteristics. This classification system formed the basis of the texture profile method, a technique that allows the mechanical, geometrical, and other textural sensations associated with a product to be defined from the first bite through complete mastication (Brandt et al., 1963).

Descriptive texture studies focus on the effects of certain critical variables, e.g., ingredient levels and processing steps, on types and magnitudes of similarities and differences among samples, and often are used as a basis for determining characteristics important to

acceptance (Abbott, 1972). The International Organization for Standardization defines the texture of a food product as all the rheological and structural (geometrical and surface) attributes of the product perceptible by means of mechanical, tactile, and, where appropriate, visual and auditory receptors (ISO, 1981). The texture of an object is perceived by the senses of sight (visual texture), touch (tactile texture), and sound (auditory texture). In some products only one of these senses is used to perceive the product texture, and in other cases the texture is perceived by a combination of these senses (Lawless & Heymenn 1998).

For the purposes of this research texture was evaluated solely on the basis of tactile perceptions in the mouth, and more specifically focusing on the body and texture of the ice cream products evaluated. An example of this would best be described by the attribute viscosity which is used for determining the thickness (viscosity) of the ice cream or gelato. The body and texture characteristics are closely associated and are important in influencing consumer acceptance of ice cream and related products (Arbuckle, 1986). Texture plays a very important role in determining people's feelings about foods (Szczesniak, 1971). In some foods, like ice cream for example, the perceived texture is the most important sensory attribute of the product, and may be even more important than flavor (Szczesniak and Kleyn, 1963).

Mouthfeel characteristics are also included in the textural profile of food products and are useful for the determination of fat content in ice cream and related dairy products. Mouthfeel characteristics are tactile but often tend to change less dynamically than most oral tactile textural characteristics. This is not the case in products such as chocolates and ice cream (Lawless & Heymenn 1998). The melting behavior of foods in the mouth and the associated texture changes have not been studied extensively, but many foods undergo a phase change in the mouth due to the increased temperature change in the oral cavity and a primary example of this is observed in the evaluation of ice cream (Lawless et al., 1996). The dynamic contrast (the moment-to-moment change in sensory texture contrasts in the mouth) is responsible for the high palatability of ice cream and other products (Hyde and Witherly, 1993).

Gelato

Gelato is an Italian frozen dessert that has very little air whipped into it and is made from a lower butterfat cream than most superpremium ice creams; superpremium ice creams contain 12-18% fat vs. gelato's 7% (Marshall et al., 2003; IDFA, 2005; Pszczola, 2002; USDEC, 2001;

Bray, 1993; Marshall and Goff, 2003). This type of frozen dessert can be purchased fresh from specialty shops, such as ice-cream parlors in the U.S. and gelaterias in Italy. Italy has the highest per capita ice cream consumption amongst EU countries (Anonymous, 2001). Approximately 33% of ice cream produced in Italy in 1991 was artisan-manufactured gelato, which has a typical formulation of 6.9% fat, 9.4% milk Solids NonFat, 19.7% sugar and 37.6% total solids (Bray, 1993); there are no legal definitions for gelato in the U.S. to date.

Gelato varies significantly by region in Italy: In the south, gelato is made with milk and no egg yolks. In central Italy, it is made from a milk and egg custard, while in the north; it is very rich due to the use of cream and eggs (Berry, 2004). The one attribute that all the gelati have in common is the use of little or no overrun, the air that is whipped into traditional American ice creams to give it a lighter texture (Anonymous, 2004). As a result, gelato is denser than American ice cream, and this density produces a more heightened flavor. The smooth, soft texture of a gelato, as well as the high flavor characteristic, provides attributes that are desired by consumers (Destephano *et al.*, 1999). One thing gelato is noted for, is its intensity of flavor; the main difference between American ice cream and gelato. American-style ice cream emphasizes body, texture, and particulates; gelato emphasizes flavor.

Major ice cream brands are now beginning to rely on innovations in flavor and form to gain market share from private labels and less-known brands (Saulnier, 1996), but still lack the variety and unique intensity of flavors that are typically associated with gelato. Hazelnut, pistachio, strawberry and raspberry, are some of the most popular flavors in the United States (Ryan, 2005). In addition to those are more innovative flavors such as blueberry, pear, chocolate with red peppers, dulce de leche, floral and herbal flavors (Rosskam, 2006). Using fresh ingredients is a key part of achieving the desired flavors, gelato artisans typically use real ingredients such as pistachio from pistachios, raspberry from raspberries and mint from actual mint leaves.

Although gelato is very popular in most European countries it has yet to hit its peak in the U.S. The main reason for this slow growth has been the dominance that American-style ice cream has had in our eating patterns. Anything untraditional usually has a hard time gaining consumer acceptance (Stogo, 1998). Ice cream alternatives such as gelato have their following, but don't nearly approach the popularity of regular ice cream (Hollingsworth, 2003). This can most likely be attributed to the fact that dairy-based gelato is typically characterized as having

low storage stability. When gelato is stored for periods of time greater than a few hours, the gelato loses its characteristic smooth, soft, silky texture (Destephano, 1999). Typical American consumers are also less educated in the "world of gelato" and are therefore less likely to spend the extra dollar a typical gelato would cost to purchase. In most European countries gelato is purchased from neighborhood Gelaterias (stores) and eaten within a short period of time. The gelato is produced on the premises whereas ice cream is generally manufactured and then purchased at the grocery store where it has been kept frozen for a while. The gelato that is sold in the United States comes in many forms. Because there are no guidelines in the United States about how to make gelato, different makers use different approaches (Ryan, 2005).

Ice Cream

Over the past 10 years ice cream consumption in the U.S has remained stable (USDA, 2006). Since 1988, Americans, on average, have been eating a little less ice cream overall but more of the higher priced, higher milk fat premium and superpremium ice creams as well as frozen yogurt and other frozen dairy products (Putnam, 2003). More than 90% of all U.S. households consume ice cream, and more than 1.6 billion gallons of it (Hollingsworth, 2003). Total U.S. production of ice cream and related frozen desserts amounted to more than 1.6 billion gallons (or 23 quarts per person), which according to the USDA, makes this country the world leader in production.

Nutritional Aspects

As a result of continued advances and improvements in the dairy industry over the years, today a wide variety of milks and other dairy products, such as ice cream, is available. The nutritional contribution of milk and dairy products play an important role in our diets. Official recommendations including the U.S. Department of Agriculture's Food Guide Pyramid (USDA, 1996), National Dairy Council's Guide to Good Eating (2007), and the USDA/Department of Health and Human Service's Dietary Guidelines for Americans (USDA/DHHS, 2000), all recognize milk and other milk products as one of the five major food groups. USDA's Food Guide Pyramid recommends 2 to 3 servings/day from the Milk, Yogurt, & Cheese Group and the USDA/DHHS advises at least 3 cups per day of fat-free or low-fat milk products. Dairy foods are considered to be the preferred source of calcium for Americans.

Calcium assists in controlling blood pressure, reduces the risk of colon cancer, puts a damper on pre-menstrual syndrome, and may lower the chances of developing kidney stones (Doheny, 2004). Milk products are well known for their calcium content. Frozen dairy products such as ice cream and gelato can be a good source of calcium in the diet as long as one doesn't overload on sugar and saturated fat. It is especially interesting to note that gelato, being a lower-fat, lower-calorie dairy product in comparison to ice cream, may be an excellent choice for satisfying that nagging sweet-tooth. Recent research suggests that calcium-rich dairy foods help in maintaining weight loss by slowing down or even stopping lost pounds from returning (Zemel, 2004).

Ice Cream Categories

Ice creams have been improving over the years and have expanded into what is called the premium category. This is a category that is not in direct competition with regular ice cream rather but is considered more of a line extension. The terms 'premium' and 'super-premium' are not legally defined, however according to federal regulations (International Dairy Foods Association, 2005), identification and description of these categories are as follows:

Ice cream: a frozen food made from a mixture of dairy ingredients containing at least 10% milk fat, before the addition of bulky ingredients, and must weigh a minimum of 4.5 to the gallon.

Superpremium ice cream: a marketing term, tends to have very low overrun, high fat content (14-16% butterfat, an overrun of up to 70%, contains stabilizers), and the manufacturer uses the best-quality ingredients.

Premium ice cream: a marketing term, tends to have low overrun and higher fat content than regular ice cream (at least 12 percent butterfat in the mix), and the manufacturer uses higher-quality ingredients.

Regular ice cream: a marketing term, meets the overrun required for the federal ice cream standard.

Flavor Categories

Vanilla

Americans annually consume a reported 20 quarts of ice cream per person (USDA, 2003). Although vanilla is the leading flavor, there are a variety of vanilla products available for use in formulating ice creams and other frozen desserts (Pszcola, 2002). Records show that about 75% of all ice cream contains vanilla flavoring (Arbuckle, 1986), constituting more than 29% of supermarket sales in 1995 (International Ice Cream Association, 1996). Vanilla has the characteristic of producing a very pleasing and palatable aroma and flavor in food such as ice cream. There is a wide variation in the flavoring efficiency of vanilla extracts and vanilla products used in ice cream. Vanilla in accordance with the Federal Standards of Identity is divided into three sections: these are pure vanilla extract, vanilla-vanillin extract, and artificial vanilla flavor (IDFA, 2006). Vanilla beans come from all over the world and each type of bean comes a different flavor as well as flavor intensity. Katzer (2007) reports that Bourbon vanilla typically from Madagascar is characterized as intense, balanced and has a somewhat dark flavor. Mexican vanilla although lesser priced is regarded as being soft with a fresh aroma and flavor. Tahitian vanilla, rarely available and expensive, is considered as more of a floral vanilla flavor. Vanillin, a chemically synthesized product lacks the quality of the natural vanilla flavor and can sometimes impart a tar or wood flavor (UCLA, 2002). Vanillas or vanilla flavors (vanillin) are prepared extracts, both alcoholic and non-alcoholic are used as pure bean extracts, blends of bean extracts, or as vanilla compounds in concentrated or diluted form (Baer, 1927).

Chocolate

For the past 50 years, chocolate and cocoa has remained the second most popular flavor for ice cream. According to the Washington D.C.–based International Ice Cream Association (1996), chocolate captures 9% of the consumer's preference vs. 29% for vanilla. Chocolate flavor is universally liked and accepted across a wide span of religious, cultural and ethnographic extremes (Piggott, 1994). The percent of chocolate ice cream compared with vanilla is, however, not as large as it might be when the popularity of other chocolate products is considered. One of the reasons for this is that chocolate ice cream is not of the same standard, uniform flavor, and quality as vanilla ice cream. The flavor quality of chocolate is described as a unique balance of

bitter and sweet with slight vanilla or vanillin notes and complex dark roast flavors which are determined by the roasting process (Hoskin, 1994; Minifie, 1999). There is also a wider difference in both the flavor and general quality of chocolate ice cream made by competing manufacturers than there is in the vanilla flavored product (Welty et al., 2001).

Fruit

The ice cream trade is a major market for fresh, frozen, and canned fruits. Fruit-flavored ice creams rank third among flavors, representing about 8% of the total amount of ice cream made, with strawberry as a traditional favorite (Steinitz, 1978). Other fruit flavors are popular in season and are consumed more or less throughout the year (Arbuckle, 1986). Fresh or fresh-frozen fruit is typically considered the best source of flavor and therefore fresh fruit ice creams have a special sales appeal (Marshall et al., 2003). A wide range of fruits is used in ice cream products creating an array of ice creams that vary in flavor quality. Previous studies and information obtained from flavor chemists have attempted to describe the "typical" flavor of a variety of fruits for mango, lemon, raspberry and strawberry.

Since mango aroma and flavor vary widely among cultivars, there is no one typical formulation of flavor components for this fruit, and few studies have investigated it's flavor composition (Wilson et al., 1990; MacLeod and Snyder, 1985). Several mango cultivars possess a peach-like flavor and aroma, while other cultivars have been described as being sweet, sour, bitter, red-green ripe, floral and citrusy (Malundo et al., 2001).

For lemon flavor, Gerard Mosciano (2005) evaluated Lemon volatile fractions and described the flavor as fresh, sweet, sour, citric, tangy, fruity, and peely. May and Fishetti (1980) determined that lemonade beverages have two distinct profile characters; one is sour, juicy and lower in sweetness, while the other is more candy-like, sweeter and less sour.

Lastly, Treatt PLC (2006), the world-leading, independent flavor and fragrance ingredient specialist, describes authentic strawberry flavor as being wholly distilled from strawberries and imparts an authentic, fresh, fruity and well-rounded strawberry flavor which is described as ripe, fruity, green, seedy, and tart character typical of strawberries.

Formulation

The composition of a standard ice cream varies somewhat in different sections of the world and in various states, depending to some extent on the availability of raw materials, legal

requirements, and general practice. The most important ice cream ingredients come from milk. The dairy ingredients are crucial in determining the characteristics of the final frozen product. The wide variety of ingredients used for production of different kinds of frozen desserts is defined by the United States Food and Drug Administration regulations. Federal regulations state that ice cream must have at least 10% milk fat, the single most critical ingredient (FDA, 2005). The use of varying percentages of milk fat affects the palatability, smoothness, color, and texture and food value of the finished product (Roland et al., 1999). Gourmet or superpremium ice creams contain at least 12% and up to 18%, milk fat (IDFA, 2005; USDEC, 2001; Pszczola, 2002). In addition to butterfat standard ice creams contain, 20% total milk solids, sweeteners, stabilizers, flavoring and dairy derived ingredients (Marshall et al., 2003).. Although some ice cream is made with a sugar content of 12%, most factories use 14% and throughout the eastern section of the United States a sugar content of 15 to 16% is common (Arbuckle, 1986). Ice cream formulations have remained fairly stagnant over the years. Sources from as far back as 1927 indicate that the average formulation of standard commercial ice creams has not changed and is still used in the industry today (Baer, 1927).

Overrun, as it is usually referred to in ice cream manufacture, is the air added to frozen dessert products to increase volume (Marshall et al. 2003). Overrun may be calculated either by volume or weight and is also an important quality determinant; a high overrun ice cream having less flavor, a drier appearance and a less stiff texture. Ice cream is sold by volume in most countries and it is economically desirable to have an overrun as high as possible without adversely affecting the character of the ice cream (Varnam, 1994). Every ice cream manufacturer can by proper control methods and appliances, control the overrun within very narrow limits (Clarke, 2004). The viscosity of the mix affects the air retaining property and is an important factor both in obtaining the proper overrun or standardizing the overrun. If a mix of lower solids content is used, the percent overrun can be adjusted accordingly, depending upon the stability and texture of ice cream desired (Baer, 1927). Ice cream overrun varies from 95-100% to 30% or less for superpremium ice cream (USDEC, 2001).

Lexicon Development

A lexicon is developed to create what may be referred to as a “list” of the specific flavors or textures of a product. The lexicon may be useful for narrowing down the attributes and for the

determination of what the product is composed of. These terms can inclusively and reliably reflect all aspects of the flavor of a product. "When we consider sensory characteristics it is fairly easy to obtain agreement about the basic tastes of sweet, salt, sour, bitter. . . . Specific terms then have to be developed for particular products in order to more accurately describe their flavor by using procedures involving trained judges (panelists)" (Piggott, J.R. & Paterson, A., 1994). The panelists' development of a product lexicon begins by first becoming familiar with a vast array of products that fall within the already established product category. The panelists then evaluate several products and use references to narrow down the flavor and texture characteristics which then become the basis for the lexicon (Drake and Civille 2002).

Through the use of descriptive sensory analysis many lexicons have been developed to describe specific flavor and texture attributes for a wide variety of products including but not limited to; French cheese (Retiveau et al. 2005), ewe's and nonewe's milk cheeses' (Barcenas et al. 2005), wine (Zamora, 2004), and roasted peanuts (Lee and Resurreccion 2004). Descriptive studies may also be useful then for the characterization of Italian gelati. Although several studies have been conducted on sensory evaluation of US ice cream, no work is being done in the area of Italian ice cream. Some studies have focused on flavor development of European ice creams (Piccinali, 1996), and many studies have focused on the flavor and textural properties of ice creams: Arbuckle (1982) looked at the flavor of ice cream and frozen dessert's affect on sales potentials; Steinitz (1978) developed a flavor overview on vanilla, fruit and nut ice cream; Stampanoni-Koeferli et al. (1996) determined flavor and texture parameters of vanilla ice cream; and in 1996, Guinard et al. studied the effects of sugars and fats on sensory properties of ice creams. To date, no terminology has been found characterizing the wide variety of Italian gelati.

Ice cream has many attributes that make it a favored food of most persons. For the purpose of this research we used attributes that have been established as being most important to the overall quality and acceptance of ice cream products. Among these are a rich sweet flavor, a smooth and resistant texture, the identity of the fruit flavors based on freshness, the overall basic tastes, and amplitude. This information was obtained from previous studies conducted in the Sensory Analysis Center at Kansas State University, Manhattan, KS. These attributes were used as the basis for the research conducted in the U.S. Ice creams available in the U.S. were reviewed and tested; the information from that study was then used as the basis for the lexicon development of Italian gelato as well as for the comparison of U.S. ice creams to Italian gelati.

References

Abbott, J.A. (1972) Sensory Assessment of Food Texture. *Food Technol.* 26(1): 40.

Arbuckle, W.S. (1982) Flavor of Ice Cream and Frozen Desserts Affects Sales Potentials. *Dairy Record*. 83(3):109-112.

Arbuckle, W.S. (1986) *Ice cream*. 4th edition. Connecticut: AVI Publishing Co.

Anonymous (2001) Euromonitor: Ice cream, yogurt, and chilled desserts. *Market Research Europe.* 33 (6): 1-26.

Anonymous (2004) "Alice's Gelato Primer." What your mother didn't tell you about gelato. <http://virtualitalia.com>

Baer, A.C. (1927) The preparation and processing of ice cream mix. Wisconsin: The Olsen Publishing Co.

Barcenas, P., Perez Elortondo, F.J. and Albisu, M. (2005) Sensory comparison of several cheese varieties manufactured from different milk sources. *J. of Sensory Studies.* 20: 62-74.

Berry, D. (2004) Ice cream outlook: Looking for a churn around. <http://www.dairyfoods.com>

Bray, F. (1993) Italian gelato: Concept for premium ice creams. *European Dairy Magazine*. 5 (1): 37-39.

Brandt, M.A., Skinner, E.Z., and Coleman, J.A. (1963) The texture profile method. *J. of Food Sci*. 28, 404-409.

Cairncross, S.E. & Sjostrom, L.B. (1950) Flavor profiles: a new approach to flavor problems." *Food Technol.* 4:308-311.

Caul. J.F. (1957) The profile method of flavor analysis. *Advances in Food Research*, 7:1-140.

Chambers, E. IV, Bowers, J.A., and Dayton, A.D. (1981) Statistical designs and panel training/experience for sensory analysis. *J. of Food Sci.* 57:521-523.

Clarke, C. (2004). The science of ice cream. Cambridge, UK. RSC.

DeRovira, D. (1996) The Dynamic Flavor Profile Method. *Food Technol.* 2: 55-60.

Destephano, J., Chida, K., Swartos, A., and Chakrabarti, S. (1999) Patent US 6 379 736.

Doheny, K. (2004) Six more reasons to love ice cream: Calcium is a powerhouse of health benefits. It even helps you shed belly fat and maintain muscle mass. *Natural Health*. 34(1) 29-32.

Drake, M.A., & Civille, G.V. (2002) Flavor lexicons. *Institute of Food Technologists Comprehensive Reviews in Food Science and Food Safety*, 2 (1): 33-40.

FDA (2005) Code of Federal Regulations. Title 21(2). <http://www.accessdata.fda.gov>

Guinard, J.X., Zoumas-Morse, C., Mori, L., Panyam, D., and Kilara, A. (1996) Effect of sugar and fat on the acceptability of vanilla ice cream. *J. Dairy Sci*. 79:1922-1927.

Hyde, R.J., and Witherly, S.A. (1993) Dynamic contrast: a sensory contribution to palatability. *Appetite,* 21, 1-16.

Hollingsworth, P. (2003) Frozen desserts: formulating, manufacturing and marketing. *Food Technol*. 57(5): 26-28, 30.

Hoskin, J.C. (1994). Sensory properties of chocolate and their development. *Am. J. Clin. Nutr. 60:1068S-70S.*

International Dairy Foods Association. (2006). Federal Standards of Identity for Dairy. <http://www.idfa.org/freg/fedstandards.cfm>

International Dairy Foods Association. (2005) What's in the ice cream aisle? Definitions of frozen dessert products. <http://www.idfa.org/facts/icmonth/page5.cfm>

International Ice Cream Association. (1996) The Latest Scoop. International Ice Cream Association. Washington, DC.

ISO. (1981) Sensory analysis vocabulary, Part 4. International Organization for Standardization. Geneva, Switzerland.

Katzer, G. (2007). Gernot Katzer's Spice Pages: Vanilla –Sensory qualities. <http://www.uni-graz.at/`katzer>

King, B.M. (1994) Sensory Profiling of vanilla ice cream: flavour and base interactions. *Food Sci. and Technol.* 27(5): 450-456.

Lawless, H.T., Tuorila, H., Jouppila, K., Viratanen, P., and Horne, J. (1996) Effects of guar gum and microcrystalline cellulose on sensory and thermal properties of a high fat model food system. *J. of Text. Stud.* 27:493-516.

Lawless, H.T., & Heymann, H. (1998) Sensory Evaluation of Food. New York: Chapman & Hall.

Lee, C.M., & Resurreccion, V.A. (2004) Descriptive profiles of roasted peanuts stored at varying temperatures and humidity conditions. *J. Sens. Stud.* 19:433-456.

Lyon, D.H., Francombe, M.A., Hasdell, T.A. and Lawson, K. (1992) *Guidelines for Sensory Analysis in Food Product Development and Quality Control*. London: Chapman & Hall.

MacLeod, A.J., and Snyder, C.H. (1985) Volatile components of two cultivars pf mango from Florida. *J. Agric. Food Chem*. 33:380-384.

Malundo, T.M.M, Shewfelt, R.L., Ware, G.O., and Baldwin, E.A. (2001) Sugars and acids influence flavor properties of mango. *J. Amer. Soc. Hort. Sci*. 126 (1):115-121.

Marshall, R.T. & Goff, H.D. (2003). Formulating and manufacturing ice cream and other frozen desserts. *Food Technol.* 57(5): 32-45.

Marshall, R.T., Goff, H.D. & Hartel, R.W. (2003) "Ice Cream" 6th edition. New York: Plenum.

May, W.A., and Fishetti, F.F. (1980) System development for flavor of the future. Presented at the AACC 64th Annual Meeting, Washington DC, October 1979.

Mazzucchelli, R. and Guinard, J.X. (1999) Comparison of monadic and simultaneous sample presentation modes in a descriptive analysis of milk chocolate. *J. of Sens. Stud.* 14: 235-248.

Meilgarrd, M., Civille,C.V., and Carr, B.T. (1991) *Sensory Evaluation Techniques*, CRC, Boca Raton, FL.

Minifie, B. (1999). "Chocolate, cocoa, and confectionary: Science and technology." p.137, Aspen Publishing, Gaithursburg, Maryland.

Mosciano, G. (2005) Organoleptic characteristics of flavor materials. *Perfumer & Flavorist.* 30: 76-81.

National Dairy Council. (2007) The benefits of dairy foods in health promotion. <http://www.nationaldairycouncil.org/NationalDairyCouncil/Health/Digest/dcd75-3Page1.htm

Ohmes, R.L., Marshall, R.T., and Heymann, H. Sensory and physical properties of ice creams containing milk fat or fat replacers. *J. Dairy Sci*. 81:1222-1228.

Piccinali, P. and Stampanoni, C.R. (1996) Sensory Analysis in flavor development: Creating new vanilla flavors in the European ice cream market. *Food Marketing & Technol.* February, 17-21.

Piggott, J.R. & Paterson, A. (1994) *Understanding natural flavors*, Glasgow: Chapman & Hall.

Pszczola, D. (2002) 31 ingredient developments for frozen desserts. *Food Technol.* 56 (10): 46-65.

Putnam, J., & Allshouse, J. (2003) Trends in U.S. per capita consumption. Amber Waves, 1 (3), 12-13. < www.ers.usda.gov/data/consumption>

Retiveau, A., Chambers, D., & Esteve, E. (2005) Developing a lexicon for the flavor description of French cheeses. *Food Qual. and Pref.* 16: 517-527.

Roland, A.M., Phillips, L.G., and Boor, K.J. (1999) Effects of fat content on the sensory properties, melting, color, and hardness of ice cream. *J. of Dairy Sci.* 82:32-38.

Rosskam, S. (2006) Global flavors and trends: Are they affecting the U.S. market? IDFA's Ice Cream Technology Conference-Presentation by David Michael and Co.

Ryan, C. (2005) Gelato in the USA. < http://www.nascore.net>

Sczcesniak, A.S. & Kahn, E.L. (1971) Consumer awareness of and attitudes to food texture. *J. of Text Stud.* 2: 280-295.

Sczcesniak, A.S. & Kleyn, D.H. (1963) Consumer Awareness of Texture and Other Food Attributes. *Food Technol.*17:74.

Specter, S.E., and Sester, C.S. (1994). Sensory and physical properties of a reduced-calorie frozen dessert system made with milk fat and sucrose substitutes. *J. Dairy Sci.* 77:708-717.

Stampanoni-Koeferli, C.R., Piccinali, P., and Sigrist, S. (1996) The influence of fat, sugar and non-fat milk solids on selected taste, flavor and texture parameters of a vanilla ice-cream. *Food Qual. and Pref.* 7(2): 69-79.

Steinitz, W.S. (1978) Flavor overview: vanilla, fruit and nut ice cream. *Dairy and Ice Cream Field*, 161(5): 78-82.

Stogo, M. (1998) *Ice cream and frozen desserts*. *A commercial guide to production and marketing*. New York: John Wiley & Sons.

Stone, H., and Sidel, J.L. (1992) *Sensory Evaluation Practices*, 2nd ed. Academic Press, Inc., Orlando, FL, pp. 206-240.

Stone, H., Sidel, J., Oliver, S., Woosley, A., and Singleton, R.C. (1974) Sensory Evaluation by Quantitative Descriptive Analysis. *Food Technol.* 28 (11): 24-34.

Suttles, M.L., and Marshall, L.T. (1993) Interactions of packages and fluorescent light with the flavor of ice cream. *J. Food Prot.* 56 (7): 4.

Treatt PLC. (2006) Strawberry treats forever. <http://www.treatt.co.uk/NewsArticle>

UCLA Biomedical library: History and Special Collections. (2002). Spices: Exotic flavors and medicines. <http://unitproj.library.ucla.edu/biomed/spice/index>

U.S. Dairy Export Council (2001). Industry Overview. <www.usdec.org>

U.S. Department of Agriculture (2006). Per Capita Consumption of Major Food Commodities. <www.USDA.gov October 2006.>

U.S. Department of Agriculture and U.S. Department of Health and Human Services. (2000) Nutrition and Your Health: Dietary Guidelines for Americans. 4th edition. Home and Garden Bulletin No. 232. <www.nal.usda.gov/ref/USDApubs/hgb.htm>

U.S. Department of Agriculture, Human Nutrition Information Service. (1996) The Food Guide Pyramid. Home and Garden Bulletin No. 252. <www.nal.usda.gov/ref/USDApubs/hgb.htm>

Varnam, A.H., & Sutherland, J.P. (1994) *Milk and milk products: Technology, chemistry and microbiology.* New York: Chapman & Hall.

Welty, W.M., Marshall, R.T., and Grun, I.U. (2001) Effects of milk fat, cocoa butter, or selected fat replacers on flavor volatiles of chocolate ice cream. *J. Dairy Sci.* 84:21-30.

Wilson, C.W., Shaw, P.E., and Knight, R.J. Importance of some lactones and 2,5-Dimethyl-4-hydroxy-3(2H)-furanone to mango aroma. (1980) *J. Agric. Food Chem.* 38:1556-1559.

Zamora, M.C., & Guirao, M. (2004) Performance comparison between trained assessors and wine experts using specific sensory attributes. *J. of Sens. Stud.* 19: 530-545.

Zemel, M. (2004) Dairy foods help burn fat speed weight loss. *Obesity Research.* 12: 582-590.

Zheng, L., Marshall, R., Heymann, H., and Fernando, L. (1997) Effect of milk fat content on flavor content of vanilla ice cream. *J. Dairy Sci.* (80)12:3133-3141.

CHAPTER 2 - Materials and Methods

Ice Cream Samples

Ice cream samples (Table 1) were purchased from a local grocery store and an ice cream specialty shop (Dillon's and Cold Stone Creamery, respectively) in Manhattan, KS and were stored in a Frigidaire Commercial Freezer (Model # FFC05K2CW) at approximately -19°C (-2°F). The freezer was cleaned out and reserved for the storage of the ice cream samples in order to minimize the effect of off flavors in the samples. Ice creams purchased at the local grocery store were held at least 24 hours and up to 1 week before serving, Cold Stone creamery samples were purchased and evaluated within the same day. Ice creams were selected based on availability. Ice creams were purchased frozen from the freezer section in either a half gallon or pint size cardboard cartons. Although ice cream samples were purchased up to one week in advance, this was not considered to affect the ice cream properties as they are specifically manufactured to maintain quality standards throughout the shelf life of the product.

Gelato Samples

Panelists traveled to Florence, Italy to evaluate Italian gelato samples (Table 2-1) and to Riverside, MO to evaluate U.S. gelato samples. Florence Italy was chosen as the test site for gelato based on the availability of multiple gelaterias in one city. Riverside, Mo was chosen as the test site for U.S. gelato due to its close proximity to Manhattan, KS.

Italian gelati were made fresh, daily, and were maintained at approximately -13°C (8˚F). The Italian samples were purchased in Styrofoam containers from local gelaterias (gelato shops); Vivoli, Perseo, Conti, and Badiani, Florence Italy. Samples were purchased one or two at a time and were evaluated within 45 minutes of purchase. Specific gelaterias were selected based on referrals from travel guides, local recommendations, and availability of specific flavor variations. Although the Italian gelati were made fresh daily, productions are considered proprietary and no information was available concerning their production procedures. Gelato samples from the U.S. were produced in a local specialty shop (Love Bites Café, Riverside, Missouri). These samples were purchased in individual 3 oz. cups and were evaluated immediately after purchase. The

U.S. gelato samples were made fresh daily, using an imported batch freezer (Carpigiani brand, model 3LB502G, Anzola dell'Emilia, Italy) designed specifically for the production of gelato.

Table 2-1 Ice Cream Flavors and Brands

Flavor	**ID**	**Brand**	**Production**
Fruit			
Apple Gelato	It. Apple	Vivoli	Florence, Italy
Banana Gelato	It. Banana	Vivoli	Florence, Italy
Coconut Ice Cream	US Coconut	Edy's	Oakland, CA
Coconut Gelato	It. Coconut	Perseo	Florence, Italy
Coconut Gelato	USG Coconut	Love Bites Café	Riverside, MO
Lemon Sorbet	US Lemon	Cold Stone Creamery	Manhattan, KS
Lemon Gelato	It. Lemon	Vivoli	Florence, Italy
Mango Ice Cream	US Mango	Edy's	Oakland, CA
Mango Gelato	It. Mango1	Vivoli	Florence, Italy
Mango Gelato	It. Mango2	Perseo	Florence, Italy
Orange Gelato	It. Orange	Vivoli	Florence, Italy
Pineapple Sherbet	US Pineap	Kroger Deluxe	Hutchinson, KS
Pineapple Gelato	It. Pineap	Vivoli	Florence, Italy
Pineapple Gelato	USG Pineap	Love Bites Café	Riverside, MO
Raspberry Sorbet	US Raspb	Cold Stone Creamery	Manhattan, KS
Raspberry Gelato	It. Raspb	Conti	Florence, Italy
Strawberry Ice Cream	US Straw	Country Club	Cincinnati, OH
Strawberry Gelato	It. Straw1	Conti	Florence, Italy
Strawberry Gelato	It. Straw2	Vivoli	Florence, Italy
Tangerine Gelato	It. Tang	Badiani	Florence, Italy
Vanilla			
Vanilla Gelato (crema)	It.Crema1	Badiani	Florence, Italy
Vanilla Gelato (crema)	It. Crema2	Vivoli	Florence, Italy
Vanilla Gelato (crema)	It.Crema3	Conti	Florence, Italy

Vanilla Gelato	USG Van	Love Bites Cafe	Riverside, MO
Vanilla Ice Cream	US Van1	Kroger Deluxe	Hutchinson, KS
Vanilla Ice Cream	US Van2	Edy's	Oakland, CA
Vanilla Ice Cream	US Van3	Blue Bunny	LeMars, IA
Vanilla Ice Cream	US Van4	Haagen Dazs	Oakland, CA
Chocolate			
Chocolate Gelato	It. Choc1	Vivoli	Florence, Italy
Chocolate Hazelnut	It. Choc 2	Vivoli	Florence, Italy
Chocolate w/Red Pepper	It.Choc3	Vivoli	Florence, Italy
Chocolate Ice Cream	US Choc1	Blue Bunny	LeMars, IA
Chocolate Ice Cream	US Choc2	Kroger Deluxe	Hutchinson, KS
Chocolate Ice Cream	US Choc3	Edy's	Oakland, CA

Panelists

Five professional panelists from the Sensory Analysis Center, at Kansas State University located in Manhattan, Kansas, U.S. participated in this study. The highly trained and experienced panelists had completed 120 hours of general training, and had an average of more than 2,000 hours of testing experience. All panelists had more than 200 hours of prior testing experience with a variety of diary products including milk, cheese, and ice cream and had used flavor profile procedures adapted from Caul (1957) and Keane (1992).

The panelists traveling to Italy had to have valid passports. Air travel and lodging arrangements for the group that included the panelists, a member of the managing staff, and a graduate student of the Sensory Analysis program at Kansas State University were made by the Sensory Analysis Center.

Product Orientation

Panel orientation was held at the Sensory Analysis Center before traveling to Italy. During the orientation sessions (10 days, 15 hours), lexicons (ice cream, fruit, chocolate, and vanilla) previously developed in the Sensory Analysis Center were used by the panel. The combined generalized lexicons consisted of 45 descriptors with definitions and references

(Appendix A and B). Because orientation was held in the U.S., without the availability of the Italian gelato samples, samples for orientation included a number of samples not included in the final study, such as sorbets and homemade gelati. Homemade gelato recipes (plain, kiwi, peach, strawberry, lemon, and mixed berry) (Appendix C) were prepared using a Lello Frozen Dessert Maker, model L2A. In an effort to become more familiar with fresh fruit flavors and dairy attributes panelists were able to use references during the orientation phase of testing (Appendix D). Panelists also understood that they could add new terms if needed during the evaluation phase.

Evaluation Procedures

Panelists evaluated 35 ice cream and gelato samples using the developed lexicon for intensities of flavor, texture and amplitude attributes. A modified texture and flavor profile method adapted from Caul (1957) and Keane (1992) was used. The flavor profile method is based on consensus data obtained from highly trained panelists. A 15-point intensity scale with a range of 0 (none) to 15 (extremely high) was used by the panelists. This method has been used in the past to study flavor and texture characteristics of French cheese (Retiveau et al. 2005); ewe's and nonewe's milk cheeses' (Barcenas 2005); soy milk (Chambers IV et al., 2006); and roasted peanuts (Lee and Resurreccion 2004). Each panelist individually assigned a score for each attribute perceived in the sample. Once all panelists finished assigning intensity scores for a sample, a discussion was held among the panelists to reach a consensus list of attributes and attribute scores for that product.

Gelato

In order to simulate testing conducted at the Sensory Analysis Center, cups, spoons, ballots, unsalted crackers, and definition/reference sheets (used in previous testing), were taken to Italy and provided to the panelists. The panelists were also provided with water and unsalted crackers to cleanse their palates. Eighteen gelato samples were evaluated over a 5 day period. Samples were purchased fresh, one or two at a time, from local gelaterias and evaluated within 30 minutes of purchase. The samples were purchased in Styrofoam containers. The samples were evaluated in the hotel room due to lack of available space in most of the gelaterias. The samples not being evaluated were stored in the hotel room refrigerator. Blind samples were served in 3.25 oz plastic cups. No references were given. The gelati were evaluated using

consensus data and were scored on a previously designed worksheet (Appendix E) based on texture, flavor, tastes and amplitude. Four additional attributes (eggy, caramelized, dark roast, and peely) were added at this point based on the specific evaluation of gelato.

In order to test the gelato in a similar manner to testing in Italy, panelists traveled to the site of production; Love Bites Café, Riverside, MO. Samples were purchased in 3 ounce servings and evaluated in twenty minute timeframes, similar to previous testing. Two samples were evaluated, a lunch break was taken, and then three samples were evaluated. Again, the gelati were evaluated using consensus data and were scored on the same worksheet designed in Italy based on texture, flavor, tastes and amplitude.

Ice Cream

The ice cream samples were evaluated over a five day period. Each day the panelists tested three ice cream samples. Each sample was evaluated in approximately thirty minutes. The ice creams were organized into flavor categories based on what was readily available. Day one focused entirely on fruit flavored ice creams, day two vanilla, day three chocolate, day four various fruit flavored ice creams and sorbets, day five focused on ice cream available from a specialty ice cream shop, The Cold Stone Creamery. To eliminate bias, no information was given to the panelists about the samples. Each panelist was given three scoops of ice cream per Styrofoam bowl (8S-J20), using a Pampered Chef Large Scoop #1790. Samples were served at ~15°C (-5°F). All samples were coded with three-digit random numbers and all orders of serving were completely randomized. No references were provided to the panelists so that the evaluation would be similar to the testing in Italy.

Data Analysis

Ice creams and gelati were organized into categories: fruits, vanillas and chocolates. Unscrambler 9.6 was performed to provide a principal component analysis (PCA) using the covariance matrix for each flavor category. PCA maps were created individually for flavor, texture and amplitude for each flavor category.

References

Barcenas, P., Perez Elortondo, F.J. and Albisu, M. 2005. Sensory comparison of several cheese varieties manufactured from different milk sources. *J. of Sensory Studies. 20*, 62-74.

Bray, F. 1993. Italian gelato: Concept for premium ice creams. European Dairy Magazine. *5*(1), 37-39.

Caul, J.F. 1957. The Profile Method of Flavor Analysis. In *Advances in Food Research*, pp. 1-40, Academic Press, New York.

Chambers, E. IV, Jenkins, A, and McGuire, B. 2006. Flavor properties of plain soymilk. J. Sensory Studies. *21*, 165-179.

Chambers, E. IV, Bowers, J.A., and Dayton, A.D. 1981. Statistical designs and panel training/experience for sensory analysis. J. Food Sci. *57*, 521-523.

Heisserer, D.M., and Chambers, E. 1993. Determination of the sensory flavor attributes of aged natural cheese. J. Sensory Studies *8*, 121-132.

Keane, P. 1992. The flavor profile. In ASTM manual: *Descriptive Analysis Testing for Sensory Evaluation*, pp. 5-15, Hootman RC, Penn.

Lee, C.M., and Resurreccion, V.A. 2004. Descriptive profiles of roasted peanuts stored at varying temperatures and humidity conditions. J. Sensory Studies *19*, 433- 456.

Magretti, T. 1997. Sweet success for Italian ice-cream. European Dairy Magazine. 9(1), 20-22.

Retiveau, A., Chambers, D., and Esteve, E. 2005. Developing a lexicon for the flavor description of French cheeses. *Food Qual. and Pref. 16*, 517-527.

Ryan, C. 2005. Gelato in the USA. Fresh Cup Magazine. [Online] Available: http://www.freshcup.com

CHAPTER 3 - Sensory Characteristics of Ice Cream produced in the United States and Italy

Abstract

This study was conducted to define and compare typical sensory characteristics of high quality Italian gelati to ice creams produced in the United States. Highly trained descriptive sensory panelists evaluated gelato samples in Italy, purchased direct from local gelaterias, and ice cream samples in the U.S., purchased from grocery stores and local shops. In general, gelati gave higher overall fruity and fruit ID scores, chocolate gelati gave higher chocolate and cocoa notes, and vanilla gelati gave higher vanilla and lower vanillin intensities than most U.S. ice creams. Gelati were consistently associated with higher density, lower firmness, and slower meltdown. When compared to U.S. ice creams, Italian gelati were characterized by specific sensory properties: “true to type” flavors; high intensity flavors that were considered to be typical to that flavor category or specific fruit and are combined with a dense, smooth texture that allows for the development of flavor, body and bloom, enhancing the perception of flavors. The research conducted in this study may be useful for ice cream manufacturers and sensory scientists. This study is the first to define sensory characteristics of high quality Italian gelati and the information may be used to produce ice cream with increased consumer liking. The descriptive attributes developed can be used for the development of new or improved of ice cream products.

Introduction

Over the past 10 years ice cream consumption in the U.S. has remained stable, averaging approximately 15 pounds of ice cream per capita (USDA 2006). However, higher priced, higher milk fat premium and superpremium ice creams sales have risen (Putnam and Allhouse 2003). A main competitor of superpremium ice cream is gelato, which has been popular in Italy and is increasing in popularity in the United States (Ryan 2005; Bray 1993). Approximately 92% of Italians consume gelato (Magretti 1997), which is most notable for its natural flavors and denseness that produces heightened flavor (Anonymous 2004; Berry 2004; IDFA 2005).

Although ice cream and gelato appear similar, there are differences. Italian gelato has little or no overrun, the air added to frozen dessert products to increase volume (Marshall et al. 2003), whereas ice cream overrun varies from 30% or less for superpremium ice cream to 95-100% for other types (USDEC 2001). Italian gelato has no stabilizers or emulsifiers that typically are used in ice creams to increase viscosity (Marshall et al. 2003; Clark 2004). Gelato is made using 4-8% butterfat (Bray 1993; Marshall and Goff 2003) and ice creams are made with at least 10% butterfat and premium and superpremium ice creams contain 12-18% fat (Marshall et al. 2003; IDFA 2005; Pszczola 2002; USDEC 2001).

In addition to compositional differences, gelato and ice cream quality differ based on differences in production and storage. Gelato typically is produced fresh using a batch freezer and is extruded immediately. Gelato is held and served at a consistent temperature, around -11˚C (12-15˚F), allowing it to be served in a highly viscous semi-frozen state (Marshall et al. 2003). U.S. style ice cream on the other hand, typically is produced using an industrial ice cream freezer that simultaneously aerates and freezes the mix. The ice cream then is stored at a temperature of about -18˚C (-0.4˚F), with an ideal serving temperature of -14 to -12˚C (6-10˚F) (Clarke 2004; IDFA 2007).

Many studies have measured sensory properties of ice cream to examine the relationship among various ingredients and sensory characteristics such as flavor and texture. Hyvönen et al. (2003) found that the nature of strawberry flavoring affects flavor perception and that modifying fat distribution influences flavor release in ice cream; dairy fat retards flavor release at the highest level (~18 %). Replacement of milk fat with tapioca dextrin or potato maltodextrin also significantly affects textural properties; increasing coarseness and wateriness and decreasing

creaminess of ice cream (Specter and Sester 1994). Stampanoni-Koeferli et al. (1996) showed that the addition of fat increased the buttery and creamy notes in ice cream as well as its mouthcoating, while increases in sugar levels increased sweetness, caramel and vanillin attributes, and decreased milkiness. Guinard et al. (1996) demonstrated that sugar and, to a lesser extent, fat were key determinants of ice cream acceptability and that too little or too much sugar or fat was detrimental to ice cream quality. Other studies also determined that higher fat content positively affected overall sensory quality of ice cream (Zheng et al. 1997; Roland et al. 1999; Ohmes et al. 1998).

No studies were found related to factors affecting the sensory properties of Italian gelato. The objectives of this study were to define typical sensory characteristics of high quality Italian gelati and to compare that to ice creams produced in the U.S.

Materials and Methods

Samples

Sensory characteristics of 14 U.S. ice creams, 3 U.S. gelati, and 18 Italian gelati, all commercially available, were evaluated (Table 3-1). Fruit, chocolate and vanilla flavored ice creams were chosen for this study based on their availability and popularity.

Ice cream samples were purchased from a local grocery store and an ice cream specialty shop (Dillon's and Cold Stone Creamery, respectively) in Manhattan, KS and were stored in a Frigidaire Commercial Freezer (Model # FFC05K2CW) at approximately -19°C (-2˚F) until testing. Cold Stone Creamery samples were purchased and evaluated within the same day; other commercial ice cream samples were tested within 1 week of purchase. To eliminate bias, no information was given to the panelists about the samples. All samples were served in a Styrofoam cup with random 3-digit numbers. Apples and water were provided for rinsing between samples.

Italian gelati were made fresh, daily, and were maintained at approximately -13°C (8˚F). The Italian samples were purchased in Styrofoam containers from local gelaterias (gelato shops); Vivoli, Perseo, Conti, and Badiani (all in Florence, Italy). Samples were purchased one or two at a time and were evaluated within 30 minutes of purchase. Specific gelaterias were selected based on referrals from travel guides, local recommendations, and availability of specific flavor

variations. Although the Italian gelati were made fresh daily, production was considered proprietary and no information was available regarding the specific production procedures. Gelato samples from the U.S. were produced in a local specialty shop (Love Bites Café, Riverside, Missouri). These samples were purchased in individual 3 oz. cups and were evaluated immediately after purchase. The U.S. gelato samples were made fresh daily, using an imported batch freezer (Carpigiani brand, model 3LB502G, Anzola dell'Emilia, Italy) made specifically for the production of gelato.

Table 3-1 Ice Cream Flavors and Brands

Flavor	**ID**	**Brand**	**Production**
Fruit			
Apple Gelato	It. Apple	Vivoli	Florence, Italy
Banana Gelato	It. Banana	Vivoli	Florence, Italy
Coconut Ice Cream	US Coconut	Edy's	Oakland, CA
Coconut Gelato	It. Coconut	Perseo	Florence, Italy
Coconut Gelato	USG Coconut	Love Bites Café	Riverside, MO
Lemon Sorbet	US Lemon	Cold Stone Creamery	Manhattan, KS
Lemon Gelato	It. Lemon	Vivoli	Florence, Italy
Mango Ice Cream	US Mango	Edy's	Oakland, CA
Mango Gelato	It. Mango1	Vivoli	Florence, Italy
Mango Gelato	It. Mango2	Perseo	Florence, Italy
Orange Gelato	It. Orange	Vivoli	Florence, Italy
Pineapple Sherbet	US Pineap	Kroger Deluxe	Hutchinson, KS
Pineapple Gelato	It. Pineap	Vivoli	Florence, Italy
Pineapple Gelato	USG Pineap	Love Bites Café	Riverside, MO
Raspberry Sorbet	US Raspb	Cold Stone Creamery	Manhattan, KS
Raspberry Gelato	It. Raspb	Conti	Florence, Italy
Strawberry Ice Cream	US Straw	Country Club	Cincinnati, OH
Strawberry Gelato	It. Straw1	Conti	Florence, Italy
Strawberry Gelato	It. Straw2	Vivoli	Florence, Italy
Tangerine Gelato	It. Tang	Badiani	Florence, Italy

Vanilla			
Vanilla Gelato (crema)	It.Crema1	Badiani	Florence, Italy
Vanilla Gelato (crema)	It. Crema2	Vivoli	Florence, Italy
Vanilla Gelato (crema)	It.Crema3	Conti	Florence, Italy
Vanilla Gelato	USG Van	Love Bites Cafe	Riverside, MO
Vanilla Ice Cream	US Van1	Kroger Deluxe	Hutchinson, KS
Vanilla Ice Cream	US Van2	Edy's	Oakland, CA
Vanilla Ice Cream	US Van3	Blue Bunny	LeMars, IA
Vanilla Ice Cream	US Van4	Haagen Dazs	Oakland, CA
Chocolate			
Chocolate Gelato	It. Choc1	Vivoli	Florence, Italy
Chocolate Hazelnut	It. Choc 2	Vivoli	Florence, Italy
Chocolate w/Red Pepper	It.Choc3	Vivoli	Florence, Italy
Chocolate Ice Cream	US Choc1	Blue Bunny	LeMars, IA
Chocolate Ice Cream	US Choc2	Kroger Deluxe	Hutchinson, KS
Chocolate Ice Cream	US Choc3	Edy's	Oakland, CA

Panelists

Five professional panelists from the Sensory Analysis Center, at Kansas State University, Manhattan, Kansas, U.S.A. participated in this study. The highly trained and experienced panelists had completed 120 hours of general training and had an average of more than 2,000 hours of testing experience. All panelists had more than 200 hours of prior testing experience with a variety of diary products including milk, cheese, and ice cream and had previously used flavor profile procedures adapted from Caul (1957) and Keane (1992).

Lexicon Development

During 15 hours of orientation, prior to testing, lexicons for ice cream, fruit, vanilla, and chocolate previously developed in the Sensory Analysis Center were used by the panel. Because orientation was held in the U.S., without the availability of Italian gelato samples, samples for orientation included a number of samples not included in the final study, such as sorbets and

homemade gelati. Panelists also understood that they could add new terms if needed during the evaluation phase. The combined generalized lexicon consisted of 45 descriptors and definitions (Tables 3-2 and 3-3).

Table 3-2 Sensory Descriptors for the Flavor Evaluation of Ice Cream and Gelato

Flavor

Overall Dairy	A general term for the aromatics associated with products made from cow's milk.
Dairy Fat	The oily aromatics reminiscent of milk or dairy fat.
Dairy-Cooked	Aromatics reminiscent of heated or processed dairy products, similar to evaporated or sweetened condensed milk.
Eggy	Aromatics associated with a cooked whole egg.
Fruity-Ripe	Aromatics, which are sweet and reminiscent of a variety of ripe fruits.
Floral	Sweet, light, slightly perfumey impression associated with flowers.
Green	An aromatic found in green/under-ripe fruit.
Vanilla	A woody, slightly chemical aromatic associated with vanilla bean.
Vanillin	The sweet aromatics and character identified with marshmallow.
Alcohol-like	The sharp, chemical medicinal impression associated with some flavoring extracts.
Chocolate Complex	A blend of cocoa and dark roast aromatics at varying intensities. This impression may also be accompanied by the following flavor notes: dairy, fruity, nutty, and sweet.
Cocoa	The aromatics associated with cocoa bean, powdered cocoa and chocolate bars. A dark brown, sweet, often musty aromatic.
Caramelized	The aromatics that are sweet, brown, and may create a rounded, full-bodied impression.
Toasted	A moderately brown, baked impression.
Dark Roast	A burnt, somewhat bitter character present in a product that has been cooked at a high temperature, typical of very strong dark coffee.
Fruit ID (Typical)	An overall intensity of the specific fresh fruit which can include juice, pulp, or peel.
Fresh	An aromatic impression associated with fresh fruit.
Fruity-Cooked	An aromatic associated with heat-processed fruit, characterized as brown
Non-Natural	A sweet, somewhat fruity, non-natural aromatic associated with candy products (e.g. lemon drops).
Overripe	Aromatics associated with fruits that are too ripe; marked by decay or decline.
Citrus-overall	Aromatics associated with commonly known citrus fruits such as fresh lemons and limes.
Filler	Impression of a thickening substance added to the base product (e.g. starch).
Peely	The sour, slightly pungent, oil-like, citrus aromatics associated with the outer skin of a citrus fruit.
Sweet	Fundamental taste sensation of which sucrose is typical.
Bitter	Fundamental taste sensation of which caffeine or quinine are typical.
Sour	Fundamental taste sensation of which citric acid is typical.
Salt	Fundamental taste sensation of which sodium chloride is typical.
Astringent	Drying, puckering, or tingling sensation on the surface and/or edges of the tongue and mouth.

Table 3-3 Sensory Descriptors for the Texture and Amplitude Evaluation of Ice Cream and Gelato

Texture	
Firmness	The force required to compress the sample between the tongue and palate (use the ice cream base only, without obvious inclusions, if present).
Density	The degree of compactness of the sample when pressed between the tongue and palate (use the ice cream base only, without obvious inclusions, if present).
Meltdown	The time required for the product to melt in the mouth when continuously pressed by the tongue against the palate. The number of seconds counted equals the numerical score (1/1000 count). Sample size is 1/3 tsp.
Viscosity	The measure of flow as the product melts on the tongue when pressed between the tongue and the palate; the more viscous the product the higher the number.
Fat Feel	Refers to the intensity of the 'oily' feeling in the mouth when the product is manipulated between the tongue and the palate; perceived fat content.
Chalkiness	Measure of dry, powdery sensation in the mouth.
Iciness	The immediate perception of crystal-like particles within the sample. This measurement is taken immediately after sample has been placed in the mouth. The crystals often dissolve quickly at first manipulation.
Seed Awareness	The perception of berry seeds while the product is in the mouth.
Fruit Awareness	The perception of fruit within the ice cream, felt while the product is in the mouth.
Mouth Coating	A sensation of having a slick/fatty coating on the tongue and other mouth surfaces.
Amplitude	
Impact	The immediate reaction to the intensity of the dominant flavor notes.
Blendedness	The combination of flavor notes that interact to create an equally balanced character in the product.
Base/Fullness	The foundation and interplay of flavor notes that gives substance to the product.
Longevity	The duration or continuation of attribute intensities after swallowing.
Bloom	The evaluation of the flavors ability to grow or “fill” the mouth, from first bite through swallowing.
Overall Amplitude	The overall impression of a product judged on three aspects: the base (body, fullness); impact and longevity; balance and blendedness. Amplitude reflects the degree to which characteristics have a base and blend, bloom, and last.

Evaluation Procedures

Panelists evaluated 35 ice cream and gelato samples using the developed lexicon for intensities of flavor, texture and amplitude attributes. A modified texture and flavor profile method adapted from Caul (1957) and Keane (1992) was used. The flavor profile method is based on consensus data obtained from highly trained panelists. A 15-point intensity scale with a

range of 0 (none) to 15 (extremely high) was used by the panelists. Each panelist individually assigned a score for each attribute perceived in the sample. Once all panelists finished assigning intensity scores for a sample, a discussion was held among the panelists to reach a consensus list of attributes and attribute scores for that product. This procedure has been used for a wide variety of product types including but not limited to: soymilk (Chambers et al. 2005), beany aroma (Vara-Ubol et al. 2004), cheese (Retiveau et al. 2005) and apple juice (Cliff et al. 2000).

Eighteen gelato samples were evaluated over a 5 day period. Samples were purchased fresh, one or two at a time, from local gelaterias and evaluated within 30 minutes of purchase. Blind samples were served in 3.25 oz plastic cups. No references were given.

In order to test the U.S. gelato in a similar manner to testing in Italy, panelists traveled to the site of production; Love Bites Café, Riverside, MO. Three gelato samples were evaluated. Samples were purchased in 3 ounce servings and evaluated in twenty minute timeframes, similar to previous testing. The gelati were evaluated using consensus data and were scored on the same worksheet designed in Italy based on texture, flavor, tastes and amplitude (Appendix E).

The U.S. ice cream samples were was evaluated over a five day period. Each day the panelists saw three ice cream samples. Each sample was evaluated in approximately thirty minutes. Each panelist was given three scoops of ice cream per Styrofoam bowl (8S-J20), using a Pampered Chef Large Scoop #1790. Samples were served at ~15°C (-5°F). All samples were coded with three-digit random numbers and all orders of serving were completely randomized. No references were provided to the panelists so that the evaluation would be similar to the testing in Italy.

Data Analysis

Ice creams and gelati were organized into categories: fruits, vanillas and chocolates. Unscrambler 9.6 was used to provide a principal component analysis (PCA) using the covariance matrix for each flavor category. PCA maps were created individually for flavor, texture and amplitude for each flavor category.

Results and Discussion

For most flavors, Italian gelati scored higher in characteristic notes (i.e. fruity, chocolate/cocoa, vanilla), flavor bloom, and fullness of flavor than the U.S. ice creams (Figures

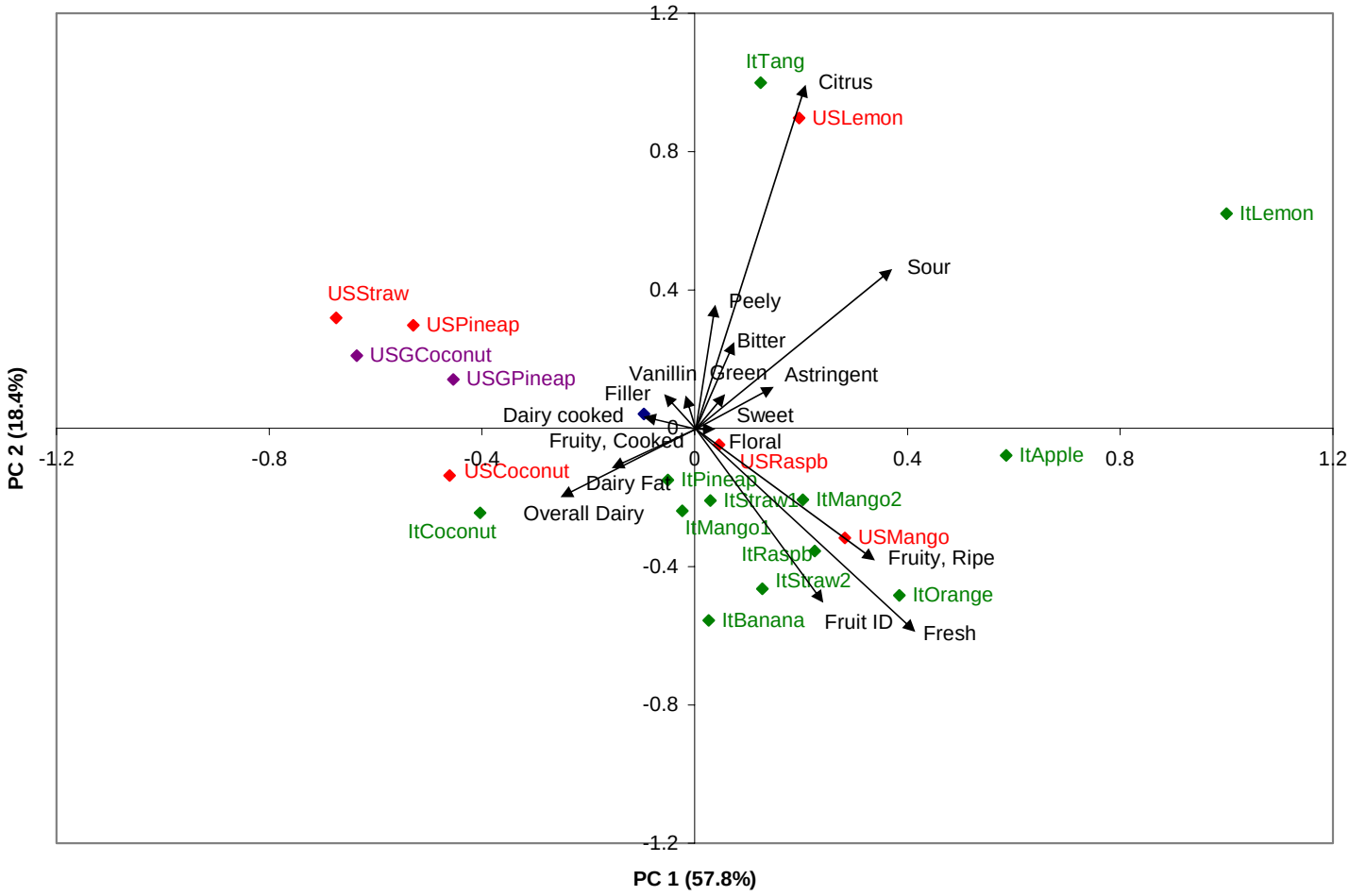
3-1 to 3-9). Overall, fruit flavored gelati from Italy were less bitter, less sweet, more sour, and more astringent than fruit flavored ice creams (Fig. 3-1). On the contrary, vanilla and chocolate gelati from Italy were sweeter than their U.S. counterparts (Figures 3-4 and 3-7). Gelati consistently were associated with higher density, lower firmness, and slower meltdown (Figures 3-3, 3-6, and 3-9). Otherwise, gelati and ice cream samples had similar intensity for textural characteristics.

Flavor Characteristics of Fruit Samples

All Italian samples of fruit flavored gelati, with the exception of coconut, were associated with fresh and fruity characteristics (Principal Component (PC) 1, Fig. 3-1), while all U.S. samples, with the exception of superpremium raspberry, mango, and lemon, are more associated with diary, cooked, and filler characteristics (PC2, Fig. 3-1). In Fig. 3-1 of the map fresh, fruit ID, fruity, floral, sour, astringent, and bitter align on the same side. Those notes typically are found in ripe, fresh fruits (Baron and Hanger 1998; Heath, 1978). Dairy, dairy fat, dairy-cooked, fruity-cooked, and filler flavor properties all appear on the opposite side of the map. Those characteristics appear more typical of dairy products (Ohmes et al. 1998; Drake 2004). Thus, the Italian gelati samples have sensory properties that are more like fresh fruit with some dairy notes, whereas the U.S. samples were more similar to dairy products with some added fruit flavor characteristics.

Interestingly, the Italian lemon gelato created somewhat of an outlier, compared to the other fruit samples because it was more fresh and fruity flavored than other products. The Italian lemon also was more sour and less sweet. These characteristics previously have been associated with fresh lemon flavors (May 1980; Baron and Hanger 1998).

Figure 3-1 The First Two Principal Components Analyzing Flavor of Fruit Ice Cream and Gelato Samples

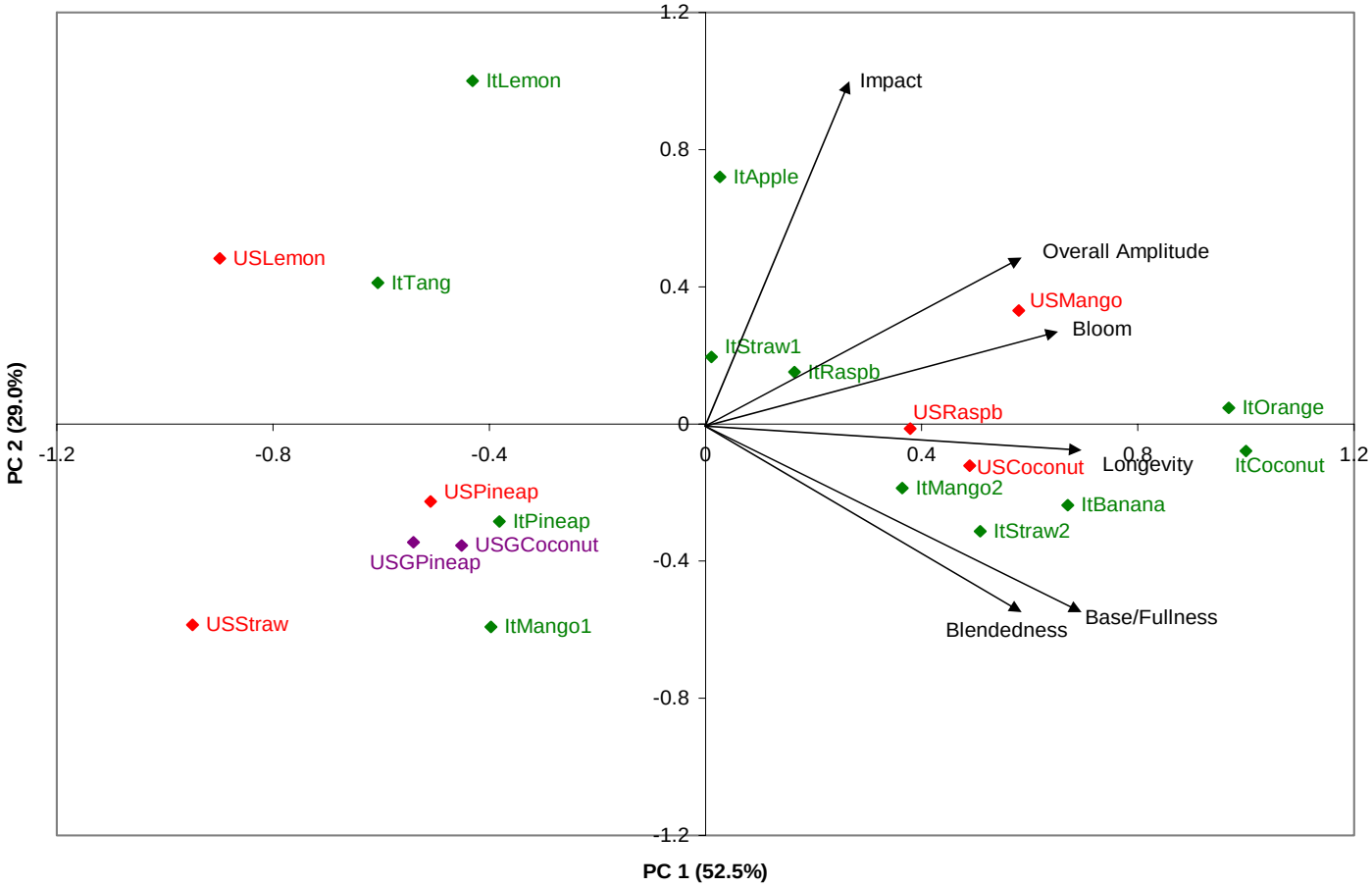


Amplitude Characteristics of Fruit Samples

Amplitude reflects the degree to which characteristics fit together and last while the product is in the mouth and immediately after swallowing. The variation in amplitude of the fruit flavored samples is driven by overall amplitude, longevity, bloom (PC1, Fig. 3-2) and impact (PC 2, Fig. 3-2). Approximately, two-thirds of the Italian samples and the more expensive U.S. ice cream products had amplitude scores that are in the upper half of the range (PC1 and PC2). Products with substantial fruit identity and fewer off-flavors appear to provide

flavor experiences that are more full and long-lasting, which may be associated with higher quality.

Figure 3-2 The First Two Principal Components Analyzing Amplitude of Fruit Ice Cream and Gelato Samples

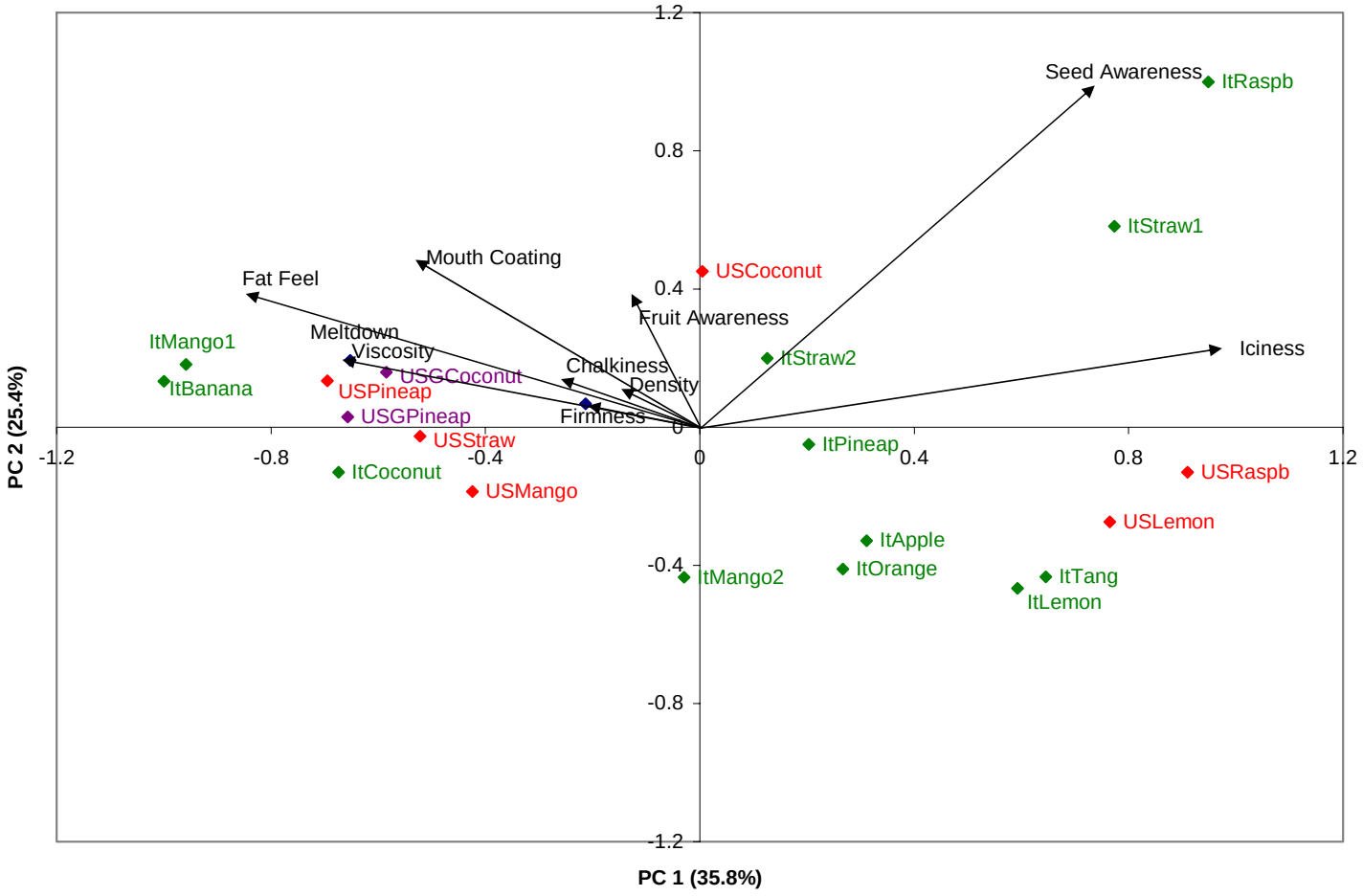


Texture Characteristics of Fruit Samples

Particle awareness drove variation in texture of the fruit samples (PC 1, Fig. 3-3). The Italian strawberry and raspberry gelato samples were high in seed awareness, which indicates the use of fresh fruit. The majority of the Italian samples and the U.S. raspberry, lemon and coconut samples also are associated with fruit awareness, which is the perception of fruit within the ice cream. The Italian strawberry sample as well as the U.S raspberry and lemon samples are driving the iciness attribute as seen on the right side of the map, this can be attributed to the fact

that the U.S samples are sorbet-type of products which are water based. Fat feel/mouthcoating-type attributes, as seen in PC 2, Fig. 3-3, are more commonly associated with dairy products such as milk and cream (Ohmes 1998). Most of the Italian samples with the exception of mango, coconut and banana, align on the opposite map from the mouthcoating/fat feel attributes. This probably is because the majority of Italian gelato is made with fresh fruits and little cream (Bray 1993). The Italian samples mango, coconut and banana found on the same side of the map as the dairy attributes are types of fruit that are naturally rich, thick and creamy, giving the impression of fat feel and mouth coating.

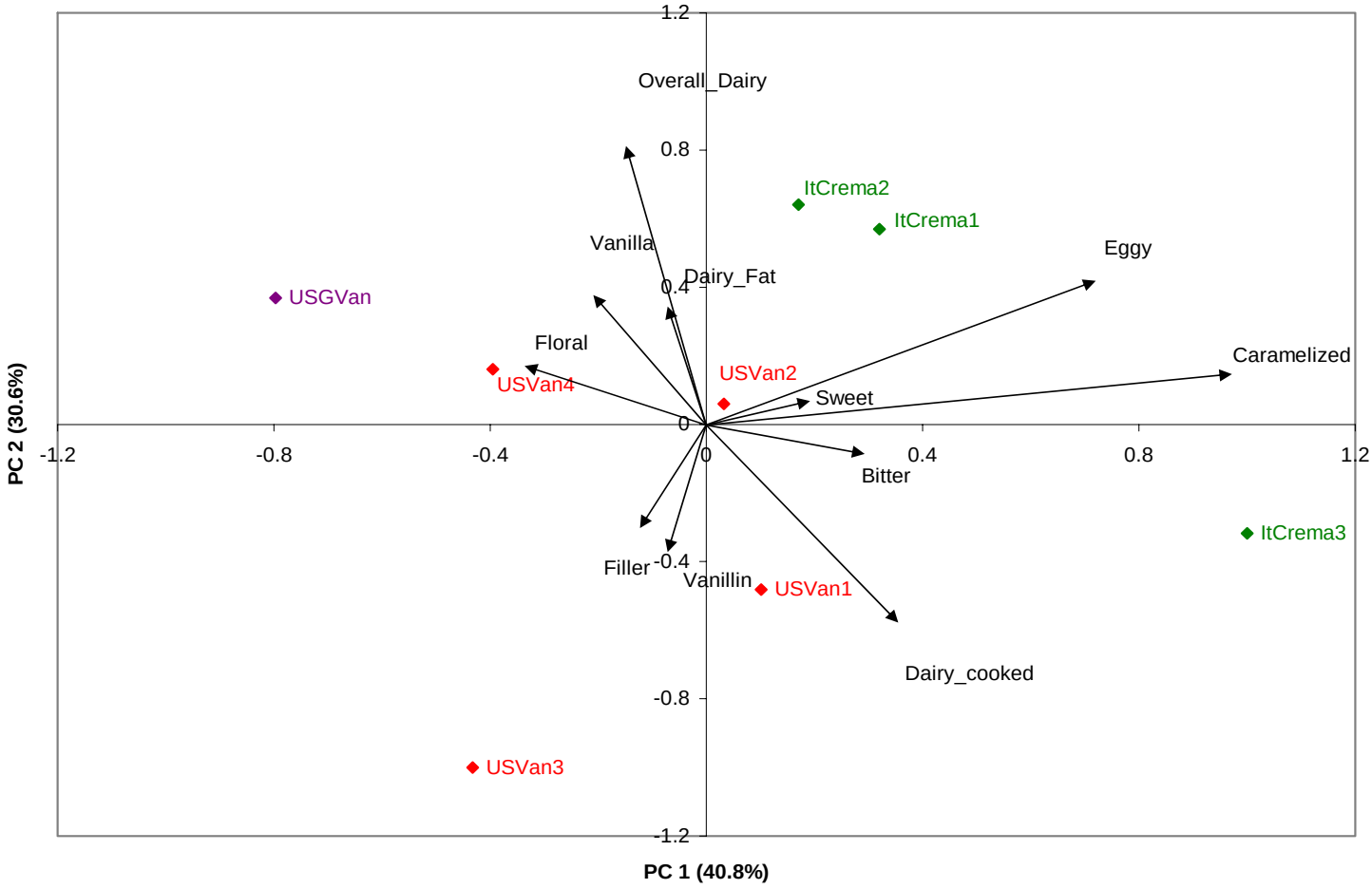
Figure 3-3 The First Two Principal Components Analyzing Texture of Fruit Ice Cream and Gelato Samples



Flavor Characteristics of Vanilla Samples

The Italian samples are characterized as eggy and caramelized (PC1, Fig. 3-4), typical descriptors of European ice creams (Piccinali 1996). The less expensive U.S. ice creams are associated with vanillin and dairy cooked flavors (PC2, Fig. 3-4), while the more expensive U.S. ice creams form a cluster around the attributes of vanilla, dairy fat and floral. Chung (2003) and Zheng (1997) determined that the increase of fat level in ice creams enhances overall vanilla intensity, and decreases vanillin perception, which explains the high vanilla scores in the higher-fat premium ice creams and high vanillin scores in regular, lower-fat ice creams similarly. Homer (1994) indicates that 'harsher' vanilla flavor notes, which normally are masked by fat, might be more intense in lower-fat products. Low scores for vanilla and higher scores for vanillin, as exemplified in some U.S. ice cream samples, may also be the result of the use of imitation vanilla or vanilla flavorings.

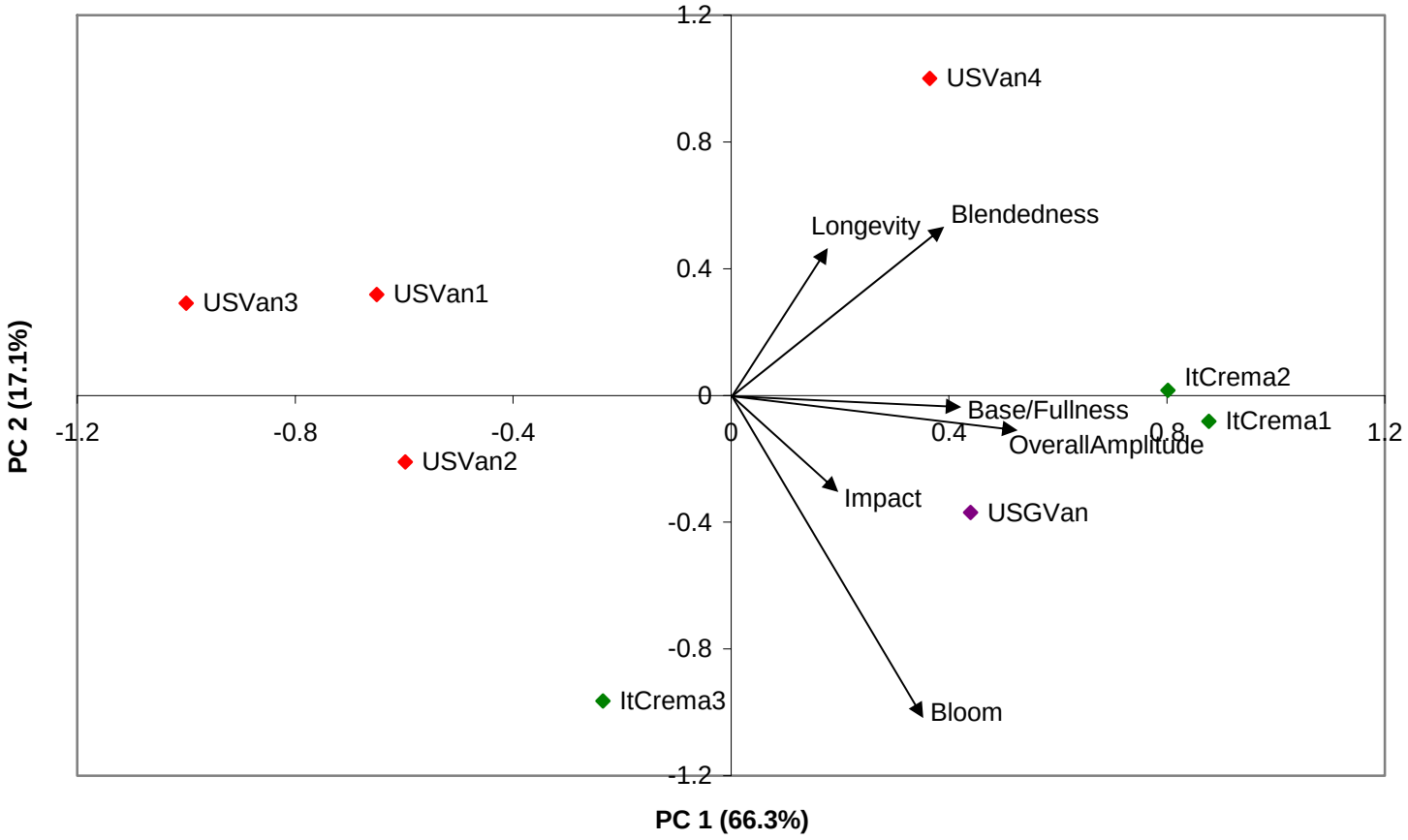
Figure 3-4 The First Two Principal Components Analyzing Flavor of Vanilla Ice Cream and Gelato Samples



Amplitude Characteristics of Vanilla Samples

For vanilla, most of the Italian samples, as well as the super premium U.S. ice cream and U.S. gelato, exhibit high scores for amplitude. The inexpensive U.S. ice creams align on the opposite side of the map indicating low scores in all amplitude measures. Inexpensive U.S. ice creams typically are lower in fat and use imitation vanilla or vanilla flavorings resulting in a product that it one dimensional and does not bloom nor last while in the mouth. The variation in amplitude is driven by base/fullness, overall amplitude and impact (PC1, Fig. 3-5), and blendedness and longevity (PC2, Fig. 3-5).

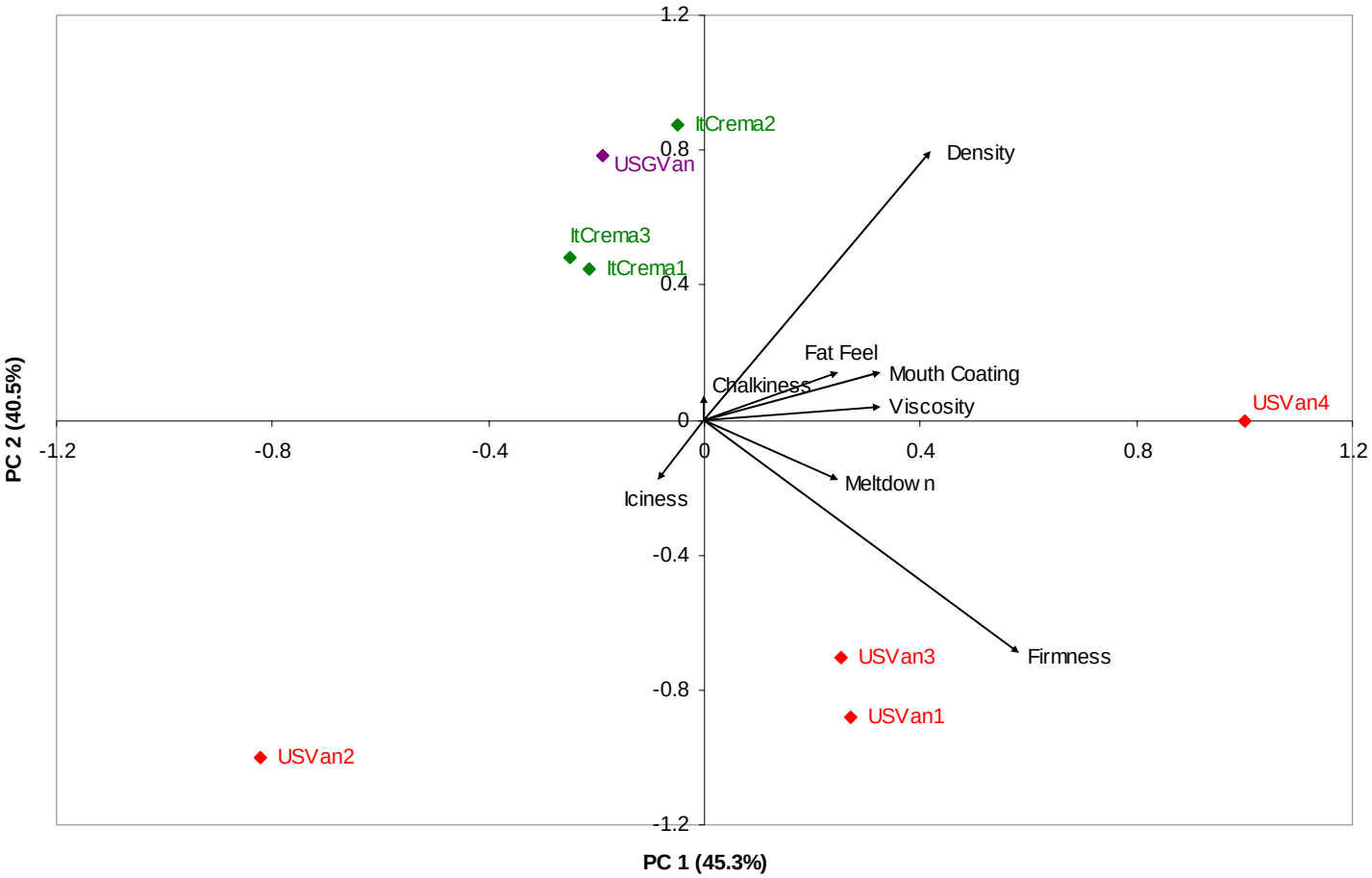
Figure 3-5 The First Two Principal Components Analyzing Amplitude of Vanilla Ice Cream and Gelato Samples



Texture Characteristics of Vanilla Samples

U.S. vanilla 1 and 3 ice creams are more firm (PC1, Fig. 3-6) and less dense (PC2, Fig. 3-6) than the Italian and U.S. gelati. This is most likely attributed to the higher amount of overrun that is incorporated into U.S. ice creams (USDEC 2001; Bray and Milano 1993). The superpremium U.SVan4 is both firm and dense; it is most likely dense due to the decrease in overrun that is typical of superpremium ice creams, it is firm as a result of its frozen storage conditions.

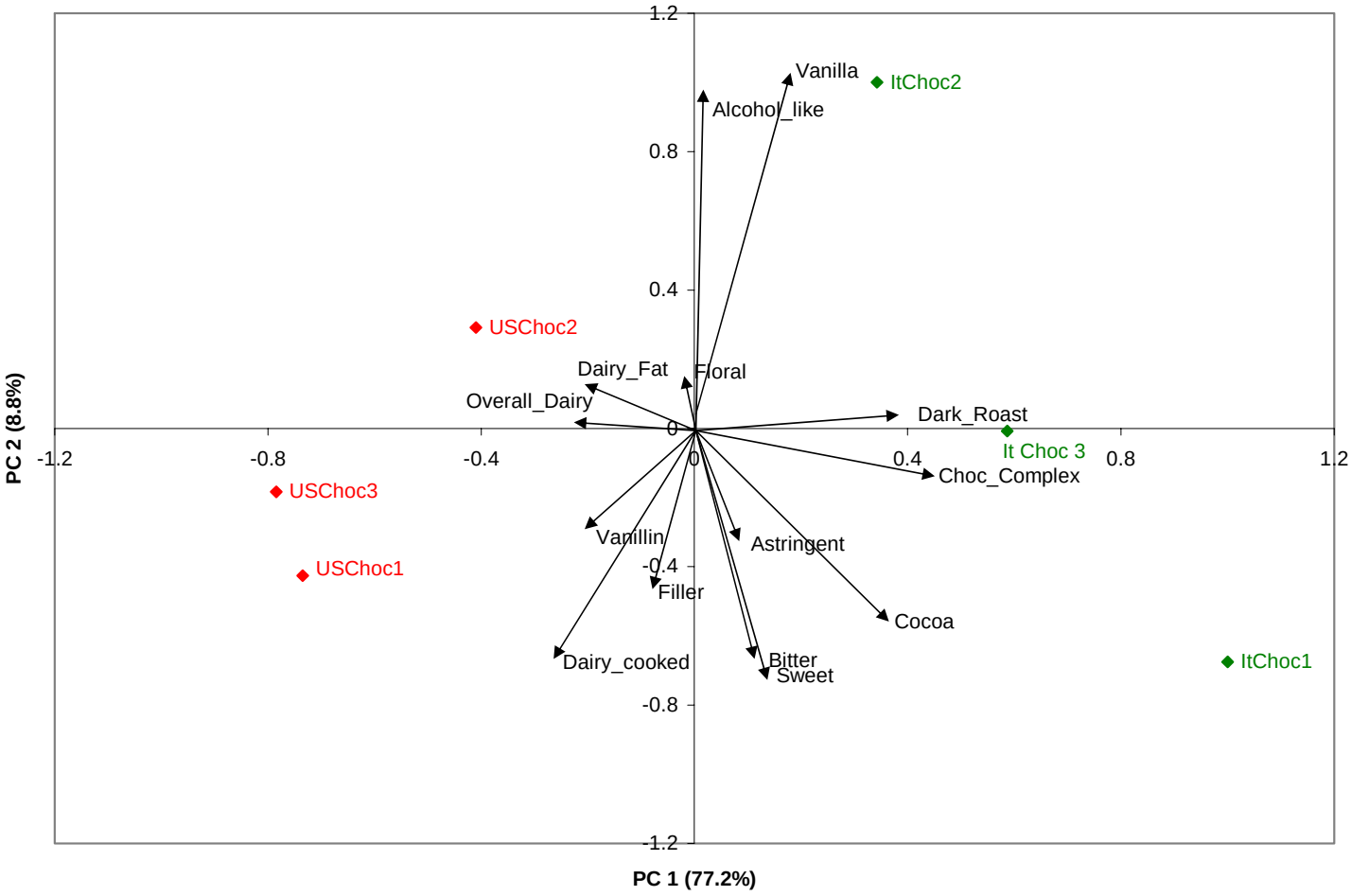
Figure 3-6 The First Two Principal Components Analyzing Texture of Vanilla Ice Cream and Gelato Samples



Flavor Characteristics of Chocolate Samples

All Italian samples are associated with chocolate complex, cocoa, and dark roast characteristics (PC1, right side of Fig. 3-7), flavor attributes typically associated with quality chocolate (Hoskin 1994; Minifie 1999). All U.S. samples are more associated with dairy, cooked and filler characteristics (PC2, Fig. 3-7); characteristics more typical of artificial chocolate products. This is largely due to great differences, both in grade or quality, in the cocoa and chocolate used for the flavor in chocolate ice creams produced in the U.S. (Welty et al. 2001).

Figure 3-7 The First Two Principal Components Analyzing Flavor of Chocolate Ice Cream and Gelato Samples

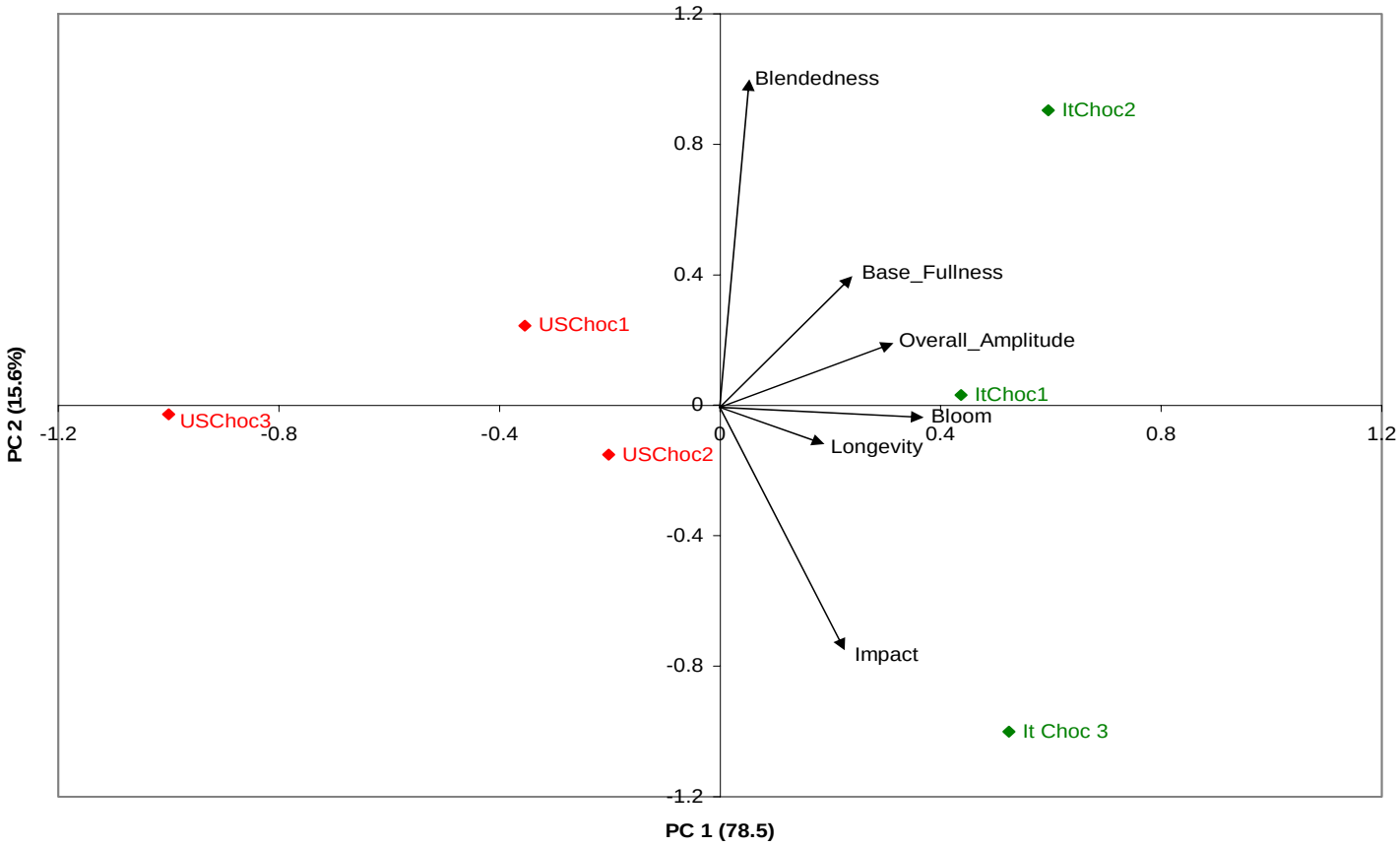


Amplitude Characteristics of Chocolate Samples

All of the Italian samples are associated with overall amplitude yet exhibit different aspects of amplitude (PC1, Fig. 3-8). ItChoc2 is more blended and has more base/fullness indicating the use of milk chocolate flavorings. ItChoc3 exhibits more impact properties which is the immediate reaction to the dominant flavor notes and their intensities demonstrating that this sample may have been flavored with a stronger, dark roast type of chocolate that has a greater impact than a more blended milk chocolate. The U.S. samples are less blended, have less base/fullness and, generally, are lower in overall amplitude. Amplitude scores are probably lower for the U.S. samples as a result of the use of imitation flavorings or rework typical in U.S. ice creams (Clark 2004). The Italian samples on the other hand have high amplitude scores as

their flavors are more complex, most likely due to the use of quality ingredients and little or no rework.

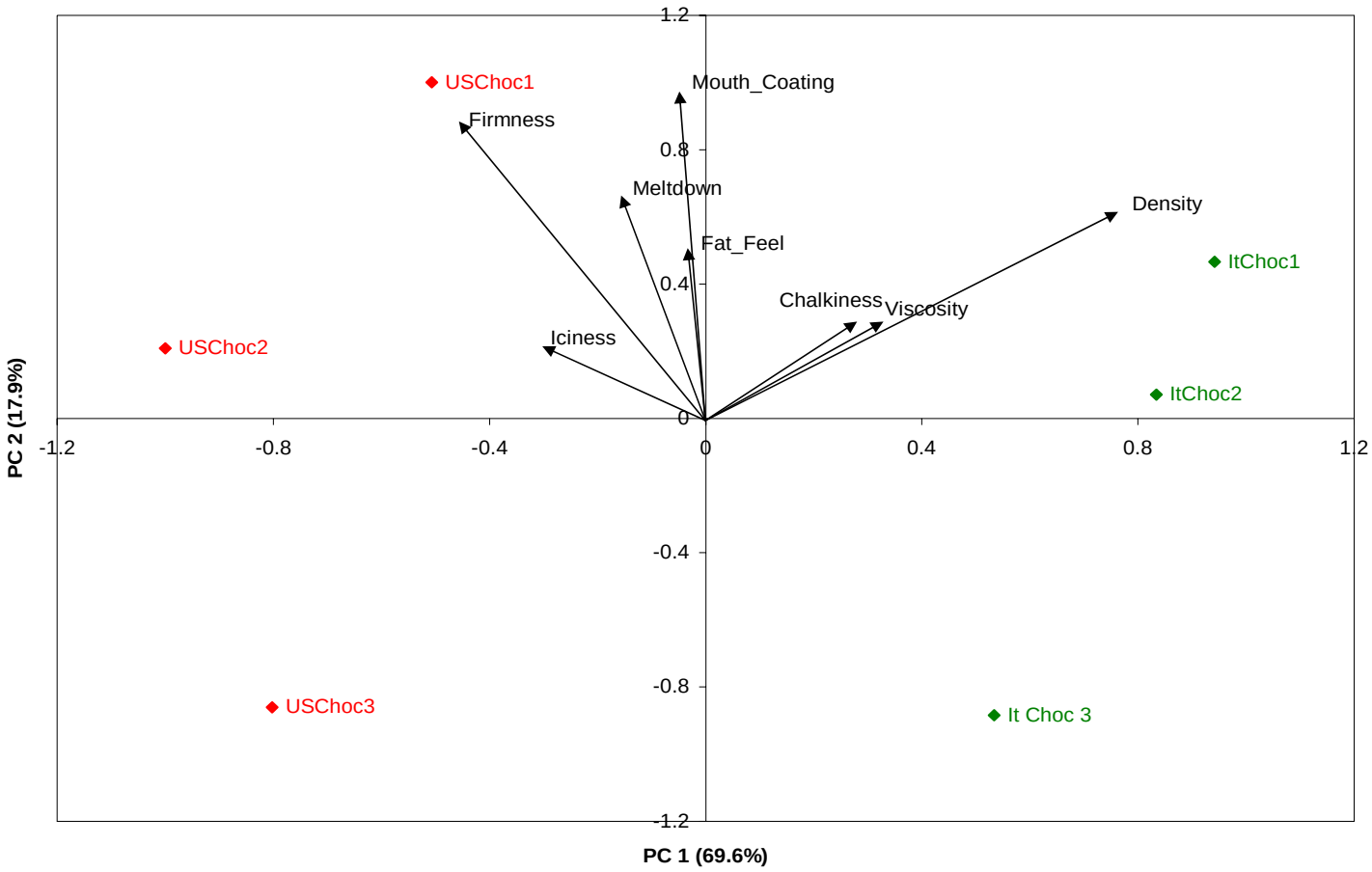
Figure 3-8 The First Two Principal Components Analyzing Amplitude of Chocolate Ice Cream and Gelato Samples



Texture Characteristics of Chocolate Samples

The U.S. chocolate ice creams are more firm, (PC 1, Fig. 3-9), and less viscous probably because of increased overrun (USDEC 2001; Bray and Milano 1993) compared to the Italian samples. The Italian products also are more dense (PC2, Fig. 3-9) and less icy.

Figure 3-9 The First Two Principal Components Analyzing Texture of Chocolate Ice Cream and Gelato Samples



Conclusions

A total of 35 Italian and United States produced ice creams were evaluated for their flavor and texture attributes. These results show that sensory characteristics of the Italian gelato samples clearly were different from many U.S. samples. The Italian gelati were most similar to higher-end U.S. ice cream samples, but differences existed even in those comparisons. When compared to U.S. ice creams, Italian gelati were characterized by "true to type" flavors; flavors that generally are intense and considered to be typical of ripe fruit in that flavor category. The fruit gelati can be described as fresh, fruity and more sour than sweet; an eating experience that is similar to eating a piece of fruit. The U.S fruit ice creams, on the other hand, had more dairy notes and some off-flavors. The chocolate and vanilla gelati, and the more expensive U.S ice creams, can also be characterized as having flavors that are associated with higher quality

ingredients including natural flavorings and extracts (e.g. cocoa powder and pure vanilla). Some U.S. samples had flavors associated with imitation flavorings.

Texturally, the Italian samples can be characterized as having a dense, smooth texture that allowed for the development of body and bloom in the flavor, resulting in enhanced perception. The U.S ice cream samples are firmer, which has been related to the increased amount of overrun typical in ice cream production, but also may be related to differences in serving temperature.

When comparing the U.S. gelati to the Italian gelati, the U.S. produced fruit gelati are more similar to U.S. ice cream than to Italian gelati samples. The flavor of the U.S. fruit gelati is more typical of dairy products with some added fruit flavor characteristics. U.S. gelati fruit samples have amplitude scores in the low end of the range whereas Italian gelati score in the upper half of the range. Additionally the texture of the U.S. gelati can also be associated with dairy-like attributes fat feel and mouthcoating. The U.S. vanilla gelato on the other hand is more similar to the Italian gelati in amplitude and texture. The flavor of the U.S. vanilla gelato is more closely related to the U.S. superpremium ice creams; exhibiting vanilla, floral and dairy fat characteristics.

The research conducted in this study may be useful for ice cream manufacturers and sensory scientists. The descriptive terms developed, defined, and referenced can be used for the development of new flavors or for the improvement of ice cream products already on the market. Ice cream can be described using this set of objectively determined sensory attributes instead of being judged subjectively by defects alone.

References

ANONYMOUS 2004. Ice cream – Gelato. [Online] Available: http://lorase.hypermart.net

ANONYMOUS 2007. What is gelato? [Online] Available: http://www.thelatestscoop.com/whatisgelato.html

BERRY, D. 2004. 2004 Ice cream outlook: Looking for a churn around. [Online] Available: http://www.dairyfoods.com/CDA/Archives.

BRANDT, M.A., SKINNER, E.Z., and COLEMAN, J.A. 1963. The texture profile method. J. Food Sci. *28*, 404-409.

BRAY, F. 1993. Italian gelato: Concept for premium ice creams. European Dairy Magazine. *5*(1), 37-39.

CAUL, J.F. 1957. The Profile Method of Flavor Analysis. In *Advances in Food Research*, pp. 1-40, Academic Press, New York.

CHAMBERS, E. IV, BOWERS, J.A., and DAYTON, A.D. 1981. Statistical designs and panel training/experience for sensory analysis. J. Food Sci. *57*, 521-523.

CHAMBERS, E. IV, JENKINS, A., and MCGUIRE, B. 2006. Flavor properties of plain soymilk. J. Sens. Stud. *21*, 165-179.

CHUNG, S.J., HEYMANN, H, and GRUN, I.U. 2003. Temporal release of flavor compounds from low-fat and high-fat ice creams during eating. J. Food Sci. *68*, 2150-2156.

CLARKE, C. 2004. *The Science of Ice Cream*, RSC, Cambridge, UK.

CLIFF, M.A., WALL, M., EDWARDS, B.J., and, KING, M. 2000. Development of a vocabulary for profiling apple juices. J. Food Qual. *23*, 73-86.

DESTEPHANO, J., CHIDA, K., SWARTOS, A., and CHAKRABARTI, S. 1999. Patent US 6 379 736.

DRAKE, M.A. 2004. Defining dairy flavors. J. Dairy Sci. *87*, 777–784.

GUINARD, J.X., ZOUMAS-MORSE, C., MORI, L., PANYAM, D., and KILARA, A. 1996. Effect of sugar and fat on the acceptability of vanilla ice cream. J. Dairy Sci. *79*, 1922-1927.

HEATH, H.B. 1978. The citrus fruits. In *Flavor Technology: Profiles, Products, Applications*, pp. 185-193, Avi, Connecticut.

HOMER, C. 1994. Flavor frenzy. Dairy Field, *177*(50), 52-4.

HOSKIN, J.C. 1994. Sensory properties of chocolate and their development. Am. J. Clin Nutr. *60*, 1068S-70S.

HYVÖNEN, L., LINNA, M., and DIJKSTERHUIS, G. 2003. Perception of melting and flavor release of ice cream containing different types and contents of fat. J. Dairy Sci. *86*, 1130-1138.

IDFA. 2007. Keep it Cool: Tips on storing and handling ice cream. [Online] Available: http://www.idfa.org/facts/icmonth/page9.cfm

IDFA. 2006. Federal standards of identity for dairy [Online] Available: http://www.idfa.org/freg/fedstandards.cfm

IDFA. 2006. Just the facts: Ice cream sales and trends. [Online] Available: http://www.idfa.org/facts/icmonth/page2.cfm

IDFA. 2005. What's in the ice cream aisle: Definitions of frozen dessert products. [Online] Available: http://www.idfa.org/facts/icmonth/page5.cfm

KATZER, G. 2007. Gernot Katzer's spice pages: Vanilla –Sensory qualities. [Online} Available: http://www.uni-graz.at/`katzer .

KEANE, P. 1992. The flavor profile. In ASTM manual: *Descriptive Analysis Testing for Sensory Evaluation*, pp. 5-15, Hootman RC, Penn.

LAWLESS, H.T., and HEYMANN, H. 1998. *Sensory Evaluation of Food*, Chapman & Hall, New York.

MAGRETTI, T. 1997. Sweet success for Italian ice-cream. European Dairy Magazine. *9*(1), 20-22.

MARSHALL, R.T., GOFF, H.D. and HARTEL, R.W. 2003. *Ice Cream*, Plenum, New York.

MARSHALL, R.T. and GOFF, D. 2003. Formulating and manufacturing ice cream and other frozen desserts. Food Technol *57*(5), 32-45.

MEILGARRD, M., CIVILLE, C.V., and CARR, B.T. 1991. *Sensory Evaluation Techniques*, CRC Press, Boca Raton.

MINIFIE, B. 1999. *Chocolate, Cocoa, and Confectionary: Science and Technology*, p. 137, Aspen, Maryland.

OHMES, R.L., MARSHALL, R.T., and HEYMANN, H. 1998. Sensory and physical properties of ice creams containing milk fat or fat replacers. J. Dairy Sci. *81*, 1222-1228.

PICCINALI, P. and STAMPANONI, C.R. 1996. Sensory analysis in flavor development: Creating new vanilla flavors in the European ice cream market. Food Marketing and Technol. *2*.

PIGGOTT, J.R. and PATERSON, A. 1994. Understanding Natural Flavors. Chapman & Hall, Glasgow.

PSZCZOLA, D. 2002. 31 ingredient developments for frozen desserts. Food Technol. *56*(10), 46-65.

PUTNAM, J. and ALLSHOUSE, J. 2003. Trends in U.S. per capita consumption. Economic Research Service USDA. Amberwaves. *1*(3), 12-13.

RETIVEAU, A., CHAMBERS, D.H., and ESTEVE, E. 2005. Developing a lexicon for the flavor description of French cheeses. Food Qual. and Pref. *16*, 517-527.

ROLAND, A.M., PHILLIPS, L.G., and BOOR, K.J. 1999. Effects of fat content on the sensory properties, melting, color, and hardness of ice cream. J. Dairy Sci. *82*, 32-38.

RYAN, C. 2005. Gelato in the USA. Fresh Cup Magazine. [Online] Available: http://www.freshcup.com

SPECTER, S.E., and SESTER, C.S. 1994. Sensory and physical properties of a reduced-calorie frozen dessert system made with milk fat and sucrose substitutes. J. Dairy Sci. *77,* 708-717.

STAMPANONI-KOEFERLI, C.R., PICCINALI, P., and SIGRIST, S. 1996. The influence of fat, sugar and non-fat milk solids on selected taste, flavor and texture parameters of a vanilla ice-cream. Food Qual. Prefer. *7*(2), 69-79.

UCLA Biomedical library: History and Special Collections. 2002. Spices: Exotic flavors and medicines. [Online] Available: http://unitproj.library.ucla.edu/biomed/spice/index

USDA. 2006. Per Capita Consumption of Major Food Commodities. [Online] Available: www.USDA.gov October 2006.

U.S. Dairy Export Council. 2001. Industry Overview. [Online] Available at www.usdec.org

VARA-UBOL, S., CHAMBERS, E. IV, and CHAMBERS, D.H. 2004. Sensory characteristics of chemical compounds potentially associated with beany aroma in foods. J. Sens. Stud. *19*, 15-26.

WELTY, W.M., MARSHALL, R.T., and GRUN, I.U. 2001. Effects of milk fat, cocoa butter, or selected fat replacers on flavor volatiles of chocolate ice cream. J. Dairy Sci. *84*, 21-30.

ZHENG, L., MARSHALL, R., HEYMANN, H., and FERNANDO, L. 1997. Effect of milk fat content on flavor perception of vanilla ice cream. J. Dairy Sci. *80*, 3133- 3141.

Appendix A - Lexicon for the Flavor Evaluation of Ice Cream and Gelato

Flavor

Overall Dairy	A general term for the aromatics associated with products made from cow's milk.
Dairy Fat	The oily aromatics reminiscent of milk or dairy fat.
Dairy-Cooked	Aromatics reminiscent of heated or processed dairy products, similar to evaporated or sweetened condensed milk.
Eggy	Aromatics associated with a cooked whole egg.
Fruity-Ripe	Aromatics, which are sweet and reminiscent of a variety of ripe fruits.
Floral	Sweet, light, slightly perfumey impression associated with flowers.
Green-Unripe	An aromatic found in green/under-ripe fruit.
Vanilla	A woody, slightly chemical aromatic associated with vanilla bean.
Vanillin	The sweet aromatics and character identified with marshmallow.
Alcohol-like	The sharp, chemical medicinal impression associated with some flavoring extracts.
Chocolate Complex	A blend of cocoa and dark roast aromatics at varying intensities. This impression may also be accompanied by the following flavor notes: dairy, fruity, nutty, and sweet.
Cocoa	The aromatics associated with cocoa bean, powdered cocoa and chocolate bars. A dark brown, sweet, often musty aromatic.
Caramelized	The aromatics that are sweet, brown, and may create a rounded, full-bodied impression.
Toasted	A moderately brown, baked impression.
Dark Roast	A burnt, somewhat bitter character present in a product that has been cooked at a high temperature, typical of very strong dark coffee.
Fruit ID (Typical)	An overall intensity of the specific fresh fruit which includes juice, pulp, or peel.
Fresh	An aromatic impression associated with fresh fruit.
Fruity-Cooked	An aromatic associated with heat-processed fruit, characterized as brown
Non-Natural	A sweet, somewhat fruity, non-natural aromatic commonly associated with candy products.
Overripe	Aromatics associated with fruits that are too ripe; marked by decay or decline.
Citrus-overall	Aromatics associated with commonly known citrus fruits such as fresh lemons and fresh limes.
Filler	Impression of a thickening substance added to the base product.
Peely	The sour, slightly pungent, oil-like, citrus aromatics associated with the outer skin of a citrus fruit.
Sweet	Fundamental taste sensation of which sucrose is typical.
Bitter	Fundamental taste sensation of which caffeine or quinine are typical.
Sour	Fundamental taste sensation of which citric acid is typical.
Salt	Fundamental taste sensation of which sodium chloride is typical.
Astringent	Drying, puckering, or tingling sensation on the surface and/or edges of the tongue and mouth.

Appendix B - Lexicon for the Texture and Amplitude Evaluation of Ice Cream and Gelato

Texture

Firmness	The force required to compress the sample between the tongue and palate (use the ice cream base only, without obvious inclusions, if present).
Density	The degree of compactness of the sample when pressed between the tongue and palate (use the ice cream base only, without obvious inclusions, if present).
Meltdown	The time required for the product to melt in the mouth when continuously pressed by the tongue against the palate. The number of seconds counted equals the numerical score (1/1000 count). Sample size is 1/3 tsp.
Viscosity	The measure of flow as the product melts on the tongue when pressed between the tongue and the palate; the more viscous the product the higher the number.
Fat Feel	Refers to the intensity of the 'oily' feeling in the mouth when the product is manipulated between the tongue and the palate; perceived fat content.
Chalkiness	Measure of dry, powdery sensation in the mouth.
Iciness	The immediate perception of crystal-like particles within the sample. This measurement is taken immediately after sample has been placed in the mouth. The crystals often dissolve quickly at first manipulation.
Seed Awareness	The perception of berry seeds while the product is in the mouth.
Fruit Awareness	The perception of fruit within the ice cream, felt while the product is in the mouth.
Mouth Coating	A sensation of having a slick/fatty coating on the tongue and other mouth surfaces.

Amplitude

Impact	The immediate reaction to the intensity of the dominant flavor notes.
Blendedness	The combination of flavor notes that interact to create an equally balanced character in the product.
Base/Fullness	The foundation and interplay of flavor notes that gives substance to the product.
Longevity	The duration or continuation of attribute intensities after swallowing.
Bloom	The evaluation of the flavors ability to grow or “fill” the mouth, from first bite through swallowing.
Overall Amplitude	The overall impression of a product judged on three aspects: the base (body, fullness); impact and longevity; balance and blendedness. Amplitude reflects the degree to which characteristics have a base and blend, bloom, and last.

Appendix C - Homemade Gelato Recipes

Gelato – Basic Recipe

1 qt whole milk
1 cup sugar
10 egg yolks
grated rind of 1 lemon, pinch of salt

Bring the milk, less half a cup, to a boil in a stainless steel saucepan (do not use an aluminum container), adding the grated lemon rind and a pinch of salt. Remove from the fire. In a bowl whip the egg yolks with the sugar. Add the cold half-cup of milk then add the hot milk a little at a time. Put the mixture in a pot on the fire and cook over very low heat for 20 minutes, stirring constantly. Do not allow to boil. When the mixture begins to thicken, pour it into a bowl and cool, stirring frequently. Strain through a fine sieve. Once entirely cooled, put the mixture in an ice-cream machine and churn until it reaches the proper consistency. Place in an ice cream freezer. NOTE: The churning time varies according to the ice cream machine used. An ice cream freezer holds a temperature just below freezing

Kiwi Gelato (www.lorase.hypermart.net)

1 cup water
4 kiwifruit; pared
½ cup sugar
5 Tablespoons lemon juice
½ Tablespoon light corn syrup
¼ teaspoon lemon peels; grated

Combine water, sugar and corn syrup in sauce pan. Cook and stir 2 minutes or until sugar is dissolved. Puree kiwi in food processor or blender to equal ¾ cup puree. Add lemon juice, peel and sugar mix. Pour into shallow metal pan and freeze for approximately 1 hour or until the mixture is firm, but not solid. When chilled, spoon into a chilled bowl and beat with an electric mixer until the mix is light and fluffy. Return it to the freezer for approximately 2 hours or until firm enough to scoop.

Lemon Gelato (Chef Meredith Kurtzman)

4 cups milk
Zest from 8 lemons
½ vanilla bean
1 and ½ cups sugar
10 egg yolks
Pinch salt

Heat the milk in a saucepan to a simmer. Put the lemon zest and vanilla bean in a bowl, and add the hot milk. When cool, cover and allow to infuse for about 8 hours or overnight in the refrigerator. Strain the milk into a sauce pan, add half the sugar, and bring to a simmer. Whisk the egg yolks with the remaining sugar until combined. Gradually dribble the hot milk into the egg yolks, half a cup at a time, whisking, to heat the yolks without cooking them. When all the milk has been added, cook the sauce over medium heat, stirring continuously, for about 4 to 5 minutes or until the sauce is thick enough to coat the back of a spoon. (Don't overcook the eggs; doing so will change the flavor of the gelato). Stir in a pinch of salt, and strain into a heatproof bowl set over ice. Cover, and refrigerate for at least 6 hours or overnight. Transfer to an ice-cream machine, and process according to directions.

Peach Gelato (www.lorase.hypermart.net)

4 cups whole milk
4 ripe peaches, peeled, pitted and chopped (about 2 cups)
1 lemon; juiced
3/4 cup sugar
4 egg yolks

In a medium saucepan, heat the milk over medium heat until bubbles form around the edges of the pan. Set aside and cover to keep hot. In a blender or food processor, puree the peaches, lemon juice, and 1/4 cup of the sugar until smooth. Set aside. In a blender or food processor, beat the remaining 1/2 cup sugar and the egg yolks together until very thick. With the machine running, gradually add the hot milk. Return the mixture to the saucepan. Cook over medium heat, stirring constantly with a wooden spoon for 6 to 8 minutes, or until the mixture thickens and coats the back of the spoon. Remove from heat and set the pan in a bowl of ice water. Stir for 2 minutes to cool the mixture. Stir in the peach mixture. Cover and refrigerate for at least 2 hours, or until thoroughly chilled. Transfer the mixture to an ice cream maker and freeze according to the manufacturer's instructions. Makes 1 1/2 quarts, serves 6.

Strawberry Gelato – Gelato Di Fragolla (www.food.epicurious.com)

1 cup minus 1 Tablespoon superfine granulated sugar
1 cup filtered water
1 pound strawberries (about 1 pint)
1 Tablespoon fresh lemon juice
1 teaspoon lightly beaten egg white

In a small heavy saucepan heat sugar and water over high heat, stirring until sugar is dissolved. Cool syrup. Trim strawberries and in a food processor puree until smooth. Transfer 2 cups puree to a bowl, reserving remainder for another use, and stir in syrup and lemon juice. Chill strawberry mixture until cold and up to 1 day. Stir in egg white and freeze in an ice-cream maker. Serve gelato immediately. Makes about 1 quart.

Mixed Berry Gelato (www.recipes.ksl.com)

¾ cup sugar
1 cup whole milk
6 oz fresh strawberries, washed and hulled
4 oz fresh blueberries, washed
5 oz fresh raspberries, washed
juice of ½ lemon
extra berries for garnish
sprigs of mint for garnish

In a saucepan combine the sugar and milk. Warm over medium heat to dissolve the sugar. Remove from heat and set aside to cool. Place the berries in a blender with the milk-sugar mixture and lemon juice. Puree until smooth. Transfer to an ice cream maker and freeze according to the manufacturers instructions.

Appendix D - Ice Cream Definition and Reference Sheet

TEXTURE

FIRMNESS: The force required to compress the sample between the tongue and palate, using the ice cream base only.

Reference: Dillon's Sour Cream = 5.5
Philadelphia Lite Cream Cheese (tub) = 9.0
Brick Kraft Philadelphia Cream Cheese = 14.0

DENSITY: The degree of compactness of the sample when pressed between the tongue and palate, using the ice cream base only.

Reference: Dillon's Sour Cream = 8.0
Kraft Philadelphia Cream Cheese = 13.0

MELTDOWN: The time required for the product to melt in the mouth when continuously pressed by the tongue against the palate. The number of seconds counted equals the numerical score (1/1,000 count).

VISCOSITY: The measure of flow as the product melts on the tongue when pressed between the tongue and the palate, the more viscous the product the higher the number is on the scale.

Reference: Jackson & Company Half & Half = 2.0
Dillon's Whipping Cream = 4.0

FAT FEEL: Related to the perceived fat content. Refers to the intensity of the "oily" feeling in the mouth when the product is manipulated between the tongue and the palate.

Reference: Dillon's ½ and ½ = 5.0
Dillon's Whipping Cream = 9.5

CHALKINESS: A measure of dry, powdery sensation in the mouth.

Reference: Eagle Brand Sweetened Condensed Milk = 13.0

ICINESS: The immediate perception of crystal-like particles within the base ice cream. This measurement is taken immediately after sample has been placed in the mouth. The crystals dissolve quickly at first manipulation.

Reference: Ice cream that has been through a thaw-refreeze cycle. (Character Reference)

SEED AWARENESS: The perception of berry seeds within the ice cream. Taste while the product is in the mouth.

FRUIT AWARENESS: The perception of fruit within the ice cream. Taste while the product is in the mouth.

MOUTH COATING: A sensation of having a slick/fatty coating on tongue and other mouth surfaces.

Reference: Jackson & Company Half & Half = 4.5
Dillons Whipping Cream = 8.0

FLAVOR

OVERALL DAIRY: A general term for the aromatics associated with products made from cow's milk

Reference: Carnation Non Fat Dry Milk = 4.5 (flavor)
Kroger Half and Half = 10.0 (flavor)

DAIRY FAT: Aromatics associated with dairy fat.

Reference: Carnation Non Fat Dry Milk = 0.0 (flavor)
Land O'Lakes Fat Free Half & Half = 5.0 (flavor)

Preparation: Mix 1 part of milk with 3 parts of water

DAIRY COOKED: Aromatics reminiscent of heated or processed dairy products, similar to evaporated or sweetened condensed milk.

Reference: Heated Milk = 4.5 (flavor)
Carnation Evaporated Milk = 13.0 (flavor)

Preparation: 1 cup Dillon's Whole Milk heated in the microwave on high for 2 minutes.

FRUITY-RIPE: Aromatics, which are sweet and reminiscent of a variety of ripe fruits.

Reference: Starburst Fruit Chew (wild cherry) = 5.0 (aroma)
Blackberry WONF 3RA654 (full strength) = 9.5 (aroma)

FLORAL: Sweet, light, slightly perfuming aromatics associated with flowers

Reference: Welch's White Grape Pear Juice = 7.0 (flavor)

Preparation: Dilute Welch's White Grape Pear Juice 1 to 1 with water.

GREEN: Aromatics associated with green vegetable vegetation that may include green, bitter notes.

Reference: Parsley = 8.0 (aroma)

Preparation: Place 1 tsp of McCormick Dried Parsley in covered snifter

VANILLA: A woody, slightly chemical aromatic associated with vanilla bean.

Reference: McCormick Vanilla Extract in Dillon's Homogenized Vitamin D Milk = 3.0 (flavor)

Preparation: Mix 1/4 tsp of extract with 4 tbsp milk.

VANILLIN: The sweet aromatics and character identified with marshmallow.

Reference: 2 g Fischer Scientific Vanillin in 250 ml of distilled water = 7.0 (aroma)

ALCOHOL-LIKE: The sharp, chemical/medicinal impression associated with some flavoring extracts.

Reference: 1/4 tsp McCormick Pure Vanilla Extract mixed with 4 tbsp Dillon's Homogenized Vitamin D Milk = 3.0 (flavor)

CHOCOLATE COMPLEX: A blend of cocoa and dark roast aromatics at varying intensities. (an overall impression). This impression may also be accompanied by the following flavor notes: dairy, fruity, nutty, and sweet.

COCOA: The aromatics associated with cocoa bean, powdered cocoa and chocolate bar. A dark brown, sweet, often musty aromatic.

Reference: Hershey's Chocolate Kiss = 8.5 (flavor)
Hershey's Cocoa in water = 12.0 (aroma) (covered)
Hershey's Chocolate Syrup = 12.0 (flavor)

NUTTY: A non-specific, slightly sweet, brown nut-like impression.

Reference: Kretschmer Wheat Germ = 7.5 (flavor)

CARAMELIZED: The aromatics that are sweet, brown, and may create a rounded, full-bodied impression.

Reference: C&H Pure Cane Brown Sugar = 7.0 (aroma) (covered)
C&H Pure Cane Brown Sugar = 9.0 (flavor)

TOASTED: A moderately brown, baked impression.

Reference:

DARK ROAST A burnt, somewhat bitter character present in a product that has been cooked at a high temperature, typical of very strong dark coffee.

Reference: Folger's Coffee Crystals = 11.5 (aroma)

Preparation: Put coffee in individual small cups and cover.

FRUIT ID (Typical): An overall intensity of the specific fresh fruit which can include juice, pulp or peel.

FRESH: An aromatic impression associated with fresh fruit.

FRUITY-COOKED: An aromatic impression associated with fresh fruit

Reference: Frozen Strawberries, thawed/cooked 3 minutes = 6.0
Smuckers Jam = 10.0

NON-NATURAL: A sweet, somewhat fruity, non-natural aromatic associated with candy products.

Reference: Strawberry Jell-O = 7.0

OVERRIPE: Aromatics associated with fruits that are too ripe; marked by decay or decline.

Reference: Blackberry WONF 3RA654 (full strength) = 8.0

CITRUS-OVERALL: Aromatics associated with commonly known citrus fruits such as fresh lemons and limes.

Reference: Fresh lemon/lime juice = 2.5
Five Alive Citrus Beverage = 4.0

FILLER: Impression of a thickening substance added to the base product.

Reference: Heinz Fat Free Classic Chicken Gravy = 11.0

PEELY: The sour, slightly pungent, oil-like, citrus aromatics associated with the outer skin of a citrus fruit.

Reference: Fresh lemon peel = 10.0

SWEET: A fundamental taste factor of which sucrose in water is typical.

Reference: 4% Sucrose Solution = 4.0
6% Sucrose Solution = 6.0
8% Sucrose Solution = 8.0

BITTER A fundamental taste factor of which caffeine in water is typical.

Reference: 0.01% Caffeine Solution = 2.0
0.02% Caffeine Solution = 3.5
0.035%Caffeine Solution = 5.0

SALT: A basic taste factor of which the taste of sodium chloride in water is typical.

Reference: 0.2% salt solution = 2.5

SOUR: The fundamental taste factor of which citric acid in water is typical.

Reference: 0.025% Citric Acid Solution = 2.0

AMPLITUDE

IMPACT: The immediate reaction to the dominant flavor notes and their intensities.

BLENDEDNESS: The combination of flavor notes that interact to create an equally balanced character in the product.

BASE/FULLNESS: The foundation and interplay of flavor notes that gives substance to the product.

LONGEVITY: The duration or continuation of attribute intensities.

BLOOM: The evaluation of a product's flavor and its ability to grow or flourish while in the mouth, from first bite through swallowing.

OVERALL AMPLITUDE: The overall impression of a product judged on three aspects; the base (body, fullness); impact and longevity; balance and blended ness. Amplitude reflects the degree to which characteristics fit together.

Appendix E - Ice Cream and Gelato Ballot

Attribute	Sample	Attribute	Sample
Texture (1/3 of teaspoon):		***Fruity:***	
Firmness			
Density		Fruit ID	
Meltdown		Fresh	
Viscosity		Cooked	
Fat Feel		Non-Natural	
Chalkiness		Overripe	
Iciness		Citrus-overall	
Seed Awareness		Filler	
Fruit Awareness		Peely	
Mouth Coating			
Flavor:		***Overall Tastes:***	
Overall Dairy		Sweet	
Dairy Fat		Bitter	
Dairy Cooked		Sour	
Eggy		Salt	
Fruity		Astringent	
Floral			
Green			
Vanilla		**Amplitude:**	
Vanillin		Impact	
Alcohol-like		Blendedness	
Chocolate Complex		Base/Fullness	
Cocoa		Longevity	
Nutty		Bloom	
Caramelized		Overall Amplitude	
Toasted			
Dark Roast			

Appendix F - Ice Cream Test Design

Date	Sample Code	Product Name	Flavor
April 12	492	Country Club Lowfat Ice Cream	Peach
	183	Kroger Deluxe Sherbet	Pineapple
	720	Country Club Lowfat Ice Cream	Strawberry
April 13	912	Kroger Deluxe Ice Cream	Vanilla
	358	Breyers Ice Cream	Vanilla
	545	Blue Bunny Ice Cream	Vanilla
	864	Haagen Dazs Ice Cream	Vanilla
April 14	266	Blue Bunny Ice Cream	Chocolate
	804	Kroger Deluxe Ice Cream	Chocolate
	637	Breyers Ice Cream	Chocolate
April 15	179	Cold Stone Creamery	Lemon
	352	Edy's Ice Cream	Coconut
	816	Cold Stone Creamery	Raspberry
April 16	428	Edy's Ice Cream	Mango

Appendix G - Gelato Test Design

Date	Sample Code	Manufacturer	Flavor
Feb. 23	397	Gelateria Conti	Strawberry
	442	Gelateria Conti	Raspberry
	118	Badiani Gelateria	Crema
	656	Badiani Gelateria	Tangerine
Feb. 25	919	Vivoli Gelateria	Pineapple
	421	Vivoli Gelateria	Mango
	176	Vivoli Gelateria	Banana
	399	Vivoli Gelateria	Orange
Feb. 26	443	Vivoli Gelateria	Chocolate
	519	Vivoli Gelateria	Chocolate Hazelnut
	763	Vivoli Gelateria	Crema
	603	Vivoli Gelateria	Lemon
	229	Vivoli Gelateria	Choc. w/Red Peppers
	971	Vivoli Gelateria	Strawberry
Feb. 27	124	Vivoli Gelateria	Apple
	425	Gelateria Conti	Crema
	746	Gelateria Perseo	Coconut
	212	Gelateria Perseo	Mango
March 21	864	Love Bites Café	Coconut
	165	Love Bites Café	Pineapple
	933	Love Bites Café	Vanilla

Appendix H - Ice Cream Product List

Date	Product Name	Manufacturer	Testing Location
April 12	Country Club Lowfat Ice Cream	Inter-American Products, Inc.	Manhattan, KS
	Kroger Deluxe Sherbet	Kroger Co.	Manhattan, KS
	Country Club Lowfat Ice Cream	Inter-American Products, Inc.	Manhattan, KS
April 13	Kroger Deluxe Ice Cream	Kroger Co.	Manhattan, KS
	Breyers Ice Cream	Unilever	Manhattan, KS
	Blue Bunny Ice Cream	Wells Dairy	Manhattan, KS
	Haagen Dazs Ice Cream	Nestlé	Manhattan, KS
April 14	Blue Bunny Ice Cream	Wells Dairy	Manhattan, KS
	Kroger Deluxe Ice Cream	Kroger Co.	Manhattan, KS
	Breyers Ice Cream	Unilever	Manhattan, KS
April 15	Cold Stone Creamery	Cold Stone Creamery, Inc.	Manhattan, KS
	Edy's Ice Cream	Nestlé	Manhattan, KS
	Cold Stone Creamery	Cold Stone Creamery, Inc.	Manhattan, KS
April 16	Edy's Ice Cream	Nestlé	Manhattan, KS
	Cold Stone Creamery	Cold Stone Creamery, Inc.	Manhattan, KS
	Cold Stone Creamery	Cold Stone Creamery, Inc.	Manhattan, KS

Appendix I - Fruit Consensus Scores

Flavor	Fruitiness	Density	Meltdown	Viscosity	Fat Feel	Chalkiness	Iciness	Seed Awareness	Fruit Awareness	Mouth Coating	Overall Dairy	Dairy Fat	Dairy cooked	Fruity, Ripe	Floral	Cream	Vanillin	Fruit ID (Typical)	Fresh	Fruity, Cooked	Citrus	Fizzy	Filler	Sweet	Bitter	Sour	Astringent	Impact	Blendedness	Base/Fullness	Longevity	Bloom	Overall Amplitude
ItStraw1	7.5	6.0	3.0	2.5	1.5	1.5	6.0	6.0	3.0	3.0	2.0	1.0	0.0	8.0	1.5	0.0	0.0	8.0	7.0	2.0	0.0	0.0	0.0	8.0	0.0	4.0	1.0	10.0	10.0	8.0	9.0	11.0	11.5
ItStraw2	7.5	7.5	5.0	3.5	2.0	0.0	3.5	3.0	2.0	2.0	3.5	2.0	1.0	10.0	2.0	0.0	0.0	10.0	9.0	1.0	0.0	0.0	0.0	9.0	0.0	3.5	1.5	9.0	12.5	12.0	8.0	11.0	12.5
ItRaspb	8.5	7.5	4.0	3.5	1.5	0.0	7.0	9.0	4.0	3.0	1.0	1.0	0.0	10.0	2.0	0.0	0.0	10.0	9.0	2.0	0.0	0.0	1.5	8.0	1.0	5.0	1.0	9.0	9.0	8.0	11.0	12.0	11.5
ItPineap	6.5	5.5	3.0	3.0	1.5	0.0	4.0	0.0	7.0	1.0	3.0	1.0	0.0	6.0	2.5	0.0	0.0	7.0	7.5	1.5	0.0	0.0	0.0	10.0	0.0	4.0	0.0	8.0	10.0	9.0	7.5	9.0	10.0
ItMangpl	8.5	8.0	5.5	6.0	3.5	2.0	1.0	0.0	3.0	5.0	3.0	1.0	0.0	8.0	1.5	0.0	0.0	7.0	7.5	1.5	0.0	0.0	0.0	10.0	0.0	2.5	2.0	7.0	10.0	6.5	8.0	8.0	9.0
ItMangpl2	6.5	7.0	3.0	4.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	8.5	4.0	0.0	0.0	8.5	8.5	0.0	0.0	0.0	0.0	9.0	2.5	4.0	3.0	9.0	11.0	10.5	10.0	11.0	11.5
ItOrange	9.0	7.5	3.0	3.5	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	2.5	1.0	0.0	11.0	11.0	0.0	0.0	0.0	0.0	9.0	1.5	4.5	2.0	11.0	12.5	10.5	12.5	13.0	12.0
ItLemon	6.0	6.0	3.0	1.5	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	2.0	2.0	0.0	12.0	14.0	0.0	12.0	1.5	0.0	10.0	2.0	13.5	5.0	14.0	7.0	6.5	8.0	8.5	12.5
ItTang	9.0	5.0	3.0	1.5	0.0	0.0	5.0	0.0	0.0	0.0	1.0	0.0	0.0	5.0	2.0	2.0	0.0	4.0	6.0	0.0	9.0	3.5	0.0	9.0	4.0	5.0	2.5	11.5	9.0	6.5	7.0	9.0	10.0
ItBanana	6.5	9.0	5.5	5.0	5.0	2.0	0.0	0.0	4.0	3.0	6.5	4.0	1.5	8.0	1.5	0.0	0.0	8.0	12.0	0.0	0.0	0.0	0.0	8.0	1.5	1.5	3.5	11.0	13.0	12.0	12.0	7.0	13.0
ItApple	7.5	6.0	4.5	1.5	0.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0	11.0	3.0	3.5	0.0	10.0	10.0	0.0	0.0	0.0	0.0	9.0	3.0	12.0	3.5	13.0	9.0	7.5	9.5	9.5	13.0
ItCoconut	8.0	8.0	4.5	3.5	4.0	1.0	0.0	0.0	0.0	3.0	8.0	4.5	1.5	2.5	2.0	0.0	0.0	8.0	6.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.5	10.5	12.0	12.0	12.5	11.5	13.0
USPineap	10.5	5.0	6.0	5.0	3.0	2.0	2.0	0.0	5.0	3.0	5.0	3.0	4.5	5.0	2.0	0.0	3.0	4.0	4.0	0.0	0.0	0.0	2.0	10.0	1.0	2.5	0.0	9.0	10.0	8.5	8.0	8.0	9.0
USStraw	10.0	4.5	6.0	5.5	3.0	2.5	2.5	0.5	0.0	2.5	5.0	3.0	4.5	3.0	1.5	0.0	4.0	3.0	0.0	3.0	0.0	0.0	4.0	10.0	1.0	0.0	0.0	7.0	10.0	8.0	7.0	6.5	7.5
USLemon	6.5	5.0	3.5	2.5	0.0	0.0	7.0	0.0	2.5	0.0	0.0	0.0	0.0	6.0	2.0	0.0	0.0	6.0	4.0	0.0	6.0	4.0	0.0	10.0	3.0	8.5	4.0	11.0	7.0	6.0	7.0	8.0	10.0
USCoconut	7.5	7.0	5.5	4.0	3.0	1.0	1.5	6.0	0.0	2.0	7.0	4.0	1.5	2.0	0.0	0.0	0.0	7.0	5.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	10.0	11.0	11.0	11.0	10.5	11.5
USRaspb	8.5	8.0	0.0	0.0	0.0	0.0	3.0	3.0	2.5	0.0	2.0	0.0	0.0	8.0	2.0	0.0	0.0	9.0	5.0	3.0	0.0	0.0	0.0	10.0	1.5	5.5	1.5	11.0	12.0	10.0	10.0	10.5	11.0
USMangp	10.0	8.0	6.0	5.5	1.5	0.0	2.0	0.0	0.0	1.5	0.0	0.0	0.0	10.0	2.0	0.0	0.0	10.0	9.0	0.0	0.0	0.0	0.0	10.0	1.5	5.0	1.5	12.0	11.0	10.0	10.0	12.0	12.5
USGPineap	9.0	6.0	6.0	3.0	5.0	0.0	1.5	0.0	3.0	2.5	6.0	4.0	0.0	4.5	2.0	0.0	0.0	5.5	1.5	7.0	0.0	0.0	0.0	9.0	1.0	3.0	0.0	8.0	10.0	8.0	9.0	7.5	9.0
USGCoconut	8.0	6.0	5.0	3.0	5.0	0.0	2.0	0.0	6.0	3.0	6.0	3.5	0.0	1.5	2.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	8.0	10.0	8.0	10.0	7.5	9.0

Appendix J - Vanilla Consensus Scores

	Firmness	Density	Meltdown	Viscosity	Fat Feel	Chalkiness	Iciness	Mouth Coating	Overall Dairy	Dairy Fat	Dairy cooked	Eggy	Floral	Vanilla	Vanillin	Caramelized	Filler	Sweet	Bitter	Impact	Blendedness	Base Fullness	Longevity	Bloom	Overall Amplitude
USVan1	11.5	6.5	7.0	5.5	6.0	0.0	1.0	4.5	7.0	5.5	4.5	2.0	0.0	2.5	2.5	2.0	0.0	8.5	0.0	7.5	11.0	10.0	9.0	9.0	10.5
USVan2	9.0	4.0	4.5	2.5	4.5	0.0	1.5	2.5	8.0	5.0	3.0	1.5	0.0	4.0	0.0	2.5	0.0	8.0	1.0	8.0	10.0	10.0	9.0	9.5	11.0
USVan3	11.0	6.5	7.0	5.5	6.5	1.0	0.0	4.5	6.5	5.5	5.0	0.0	0.0	2.0	2.5	0.0	2.0	8.0	0.0	7.5	11.0	10.0	8.0	8.5	9.5
USVan4	13.0	11.0	6.0	5.5	7.0	0.0	0.0	6.0	7.5	7.5	2.5	0.0	2.0	4.0	0.0	2.0	0.0	8.5	0.0	8.5	12.0	12.0	11.0	9.0	12.0
ItCrema1	7.5	8.5	5.0	4.0	5.5	0.0	0.0	5.0	10.0	7.0	4.0	3.5	0.0	3.5	0.0	3.0	0.0	9.0	0.0	9.0	13.0	12.0	9.0	11.0	13.0
ItCrema2	6.5	9.5	6.0	5.0	7.0	1.0	0.0	5.0	10.0	7.0	2.0	4.0	0.0	3.0	2.0	2.5	0.0	8.5	0.0	8.0	13.0	12.0	9.0	11.0	13.0
ItCrema3	8.0	9.5	5.0	4.0	4.5	1.0	0.0	3.0	6.0	5.5	5.0	3.0	0.0	3.0	0.0	6.0	0.0	9.0	2.0	8.5	10.0	11.0	8.5	11.0	11.0
USGVan	7.0	9.5	4.5	4.5	6.5	0.0	0.0	4.0	9.0	6.0	2.0	0.0	2.0	5.0	0.0	0.0	0.0	8.0	0.0	9.0	11.0	12.0	10.0	11.0	12.0

Appendix K - Chocolate Consensus Scores

	Firmness	Density	Meltdown	Viscosity	Fat Feel	Chalkiness	Iciness	Mouth Coating	Overall Dairy	Dairy Fat	Dairy cooked	Floral	Vanilla	Vanillin	Alcohol like	Choc Complex	Cocoa	Dark Roast	Filler	Sweet	Bitter	Astringent	Impact	Blendedness	Base Fullness	Longevity	Bloom	Overall Amplitude
USChoc1	10.5	6.0	6.0	5.0	5.0	2.0	1.5	3.0	6.5	4.5	4.5	0.0	1.5	1.5	0.0	8.0	8.0	0.0	2.0	10.0	5.0	1.5	9.0	11.0	9.5	10.0	10.0	10.0
USChoc2	11.0	5.0	5.0	3.5	4.0	1.0	2.5	2.0	5.5	4.0	3.0	1.0	1.0	1.5	1.0	9.0	7.5	1.0	0.0	9.0	5.5	1.5	10.0	10.5	9.0	10.5	10.0	11.0
USChoc3	8.5	4.0	4.0	3.5	3.5	1.0	2.0	2.0	5.0	3.5	3.5	0.0	0.0	2.0	0.0	7.0	7.0	0.0	0.0	9.0	5.0	2.0	8.5	10.5	8.0	9.5	7.0	8.5
ItChoc1	7.5	9.5	4.0	6.0	3.5	3.5	1.0	3.0	3.5	2.0	1.5	0.0	2.0	0.0	0.0	12.0	11.0	4.0	0.0	11.0	7.0	3.0	11.5	11.5	10.5	13.0	11.0	12.5
ItChoc2	7.5	9.5	4.0	5.0	4.5	2.0	0.0	2.0	4.5	3.0	1.5	0.0	3.5	0.0	1.5	10.0	9.0	2.5	0.0	9.5	5.0	2.0	10.0	12.5	12.0	12.0	12.5	13.0
It Choc 3	7.5	7.5	4.0	5.5	3.5	2.5	0.0	0.0	3.5	2.0	2.0	0.0	2.0	0.0	0.0	11.0	10.0	3.0	0.0	10.0	5.0	1.5	12.5	9.0	10.5	12.0	12.5	12.0

View publication stats